DOCUMENT RESUME

ED 180 813 SE 029 542

AUTHOR	Long, David C.; Powell, Nancy A.
TITLE	Field Ecology, Grades 10-12.
INSTITUTION	Rocky River Public Schools, Ohio.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.; Ohio State Dept. of Education, Columbus. Div. of Research, Planning, and Evaluation.
PUB DATE	[77]
NOTE	90p.; Contains occasional light and broken type
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Biology; Conservation (Environment); *Conservation Education; Earth Science; *Ecology; Environment; *Environmental Education; Field Trips; Natural Resources; *Outdoor Education; Pollution; Science Activities; *Science Education; Secondary Education; Teaching Guides; Water Pollution Control; Water Resources

ABSTRACT

Presented are activities which provide a program of first-hand experiences in field ecology for groups of three to five students under the leadership of a teacher or adult volunteer. Concentration is centered upon study of the effects of environment on living plants and animals and the interdependence of members of ecosystems. Each investigation includes background discussion, objectives, a list of needed materials, procedure, evaluation, recommendations for further investigation, and references. The sequence of investigations is designed for completion in a one-semester program. (RE)

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FIELD ECOLOGY

GRADES 10-12

Developed by
Rocky River City Schools

Gordon E. Rodeen, Superintendent
Peter Metro, Project Director

SE 029 542

INSTRUCTIONAL MATERIALS EXCHANGE

Distributed by OHIO DEPARTMENT OF EDUCATION
Division of Planning and Evaluation

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The activity which is the subject of this report was supported in whole or in part by the U.S. Office of Education, Department of Health, Education and Welfare and the Ohio Department of Education, Division of Planning and Evaluation. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education or the Ohio Department of Education and no official endorsement by the U.S. Office of Education or the Ohio Department of Education should be inferred.

FOREWORD

The Division of Planning and Evaluation of the Ohio Department of Education is pleased to announce the Instructional Materials Exchange program. This pilot venture is being conducted in cooperation with the following developer school districts:

Ashland County-West Holmes Joint Vocational School
Cincinnati Public Schools
Cleveland Public Schools
Columbus Public Schools
Parma City Schools
Rocky River City Schools
Struthers City Schools

The materials included within the series were developed under grants awarded to the above mentioned school districts by the Division of Planning and Evaluation during the past two years.

The Instructional Materials Exchange has been initiated so that more Ohio school districts can benefit from developmental project efforts by adopting practical educational products and ideas into their systems. If this pilot effort is successful, as evidenced by sufficient numbers of educators requesting materials, the dissemination effort will be expanded to include a greater variety of educational products.

The products included in this program were selected for use by Division staff members on the basis of effective field test results and the potential of the products to be used by a greater number of schools. Distribution is being made to schools without charge as long as a supply remains available.

To permit the maximum number of schools to participate, the volume of materials that may be obtained has been limited. Permission is granted by the Ohio Department of Education and the respective school districts, however, for local reproduction of the materials in any quantity desired. Reproduction beyond the intended scope of this program, such as for commercial distribution, is prohibited.

We welcome your comments regarding the materials provided, as well as your recommendations for future inclusions of products and ideas within the Instructional Materials Exchange program.

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USE OF MATERIALS

An understanding of the biological needs of all living things is essential to wise utilization of natural resources by individuals and governments. A study of ecology is one way of gaining such an understanding.

Field ecology is a one semester program designed for students who have successfully completed high school biology. The activities are not developed in a vertical hierarchy. Therefore, individual activities can be utilized to support biology, chemistry and other science disciplines.

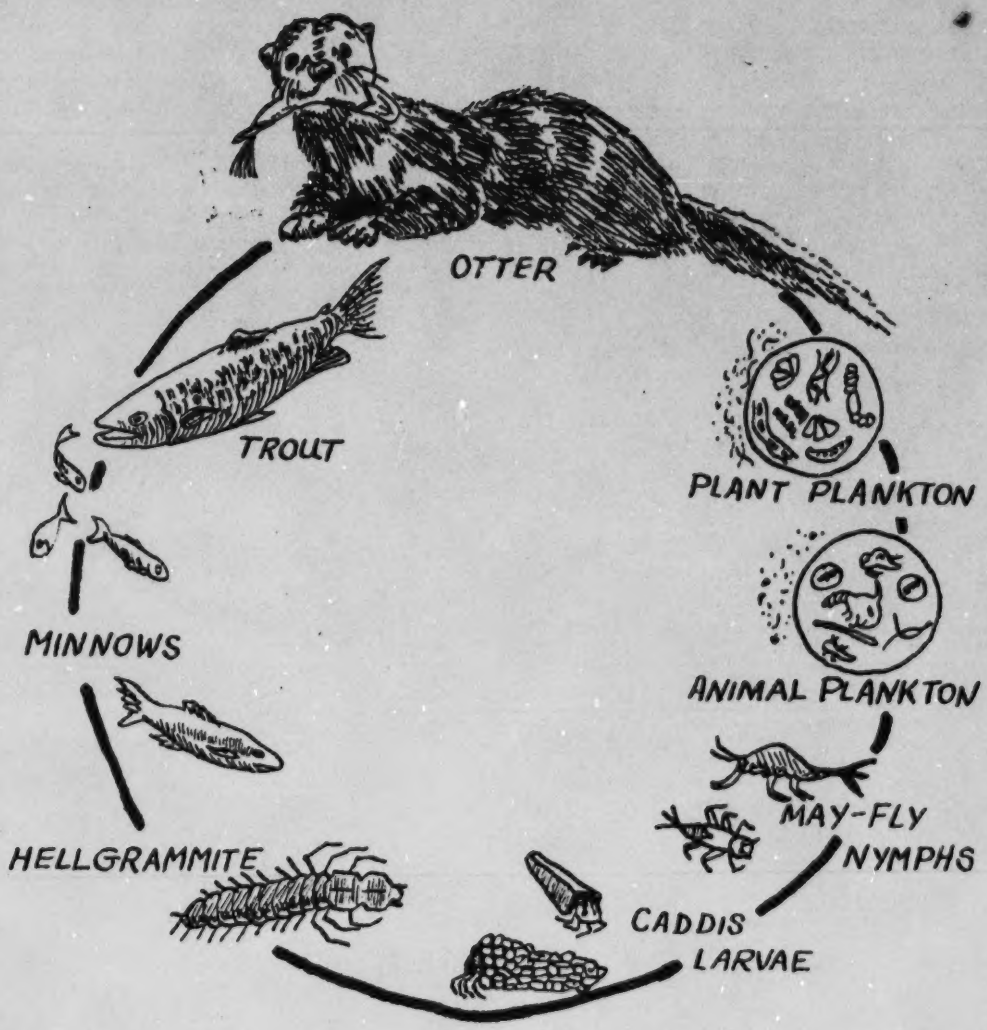
The activities presented provide a program of action. Through first hand experiences, groups of three to five students under the leadership of a teacher and/or an adult volunteer instructor may observe the effects of environment on living plants and animals. The interdependence of plants and animals will also become evident.

Although the field laboratory experiences focus on the ecology of the Rocky River-Lake Erie region, this program can be used as a resource model in any area where natural aquatic and terrestrial habitats are available.

Promotion and improvement of student attitudes is an educational goal which encompasses all field ecology activities, with the development of respect for nature and nature's laws an expected outcome. Respecting life, both plants and animals, and developing a sense of responsibility toward wise use of natural resources are additional educational goals of the program.

Further, it is hoped that student involvement in this ecological study will develop a sense of dignity in purposeful outdoor work and provide an opportunity for students to sharpen their skills in observing and interpreting natural happenings.

SIMPLIFIED FOOD CHAIN



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"Adapted from drawing by Ned Smith, courtesy of the National Audubon Society"

A. McCluer

INVESTIGATION #1

What is an Ecosystem? Build Your Own!

Background:

Ecosystem is a word which was coined by the German Botanist Ernst Haeckel. The concept of an ecosystem is a set of plants and animals living together and their interaction in a particular environment.

The ecosystem concept pulls together the physical and biological environment as they interact. An ecosystem may be open or closed. A closed ecosystem is one where outside factors have little effect on the system's basic environment. All the organisms within the ecosystem depend on each other. A simplified example of a closed ecosystem is a lake or pond. Lakes and ponds are closed ecosystems because they have definite boundaries and all biological life is confined to these boundaries. Most terrestrial ecosystems are considered open. There are any number of inputs and outputs from the system. Also, the terrestrial ecosystem very rarely has definite boundaries. For further information on ecosystems see:

Odum pp. 8–36

Objectives:

1. Student can define the limits of an ecosystem.
2. Student can determine the function of each component of the ecosystem.

Materials:

gallon jar or fish tank
pond water
sand, mud or stones
producers — of your choice
consumer — of your choice
decomposer

Procedure:

1. Define a closed ecosystem. Determine the different components which should be included in a balanced ecosystem. Discuss the role of each component in your ecosystem. Have these questions checked by your instructor before you continue.
2. Build your ecosystem as defined by the limits you developed. Use a gallon jar or fish tank. Collect what you need for your ecosystem. You may have to check with your instructor for help in locating the materials needed.
3. During the next month check your ecosystem twice per week. What data do you want to collect after each observation? What information do you need to know if your system is balanced? Why? Check with your instructor to see if you have made correct choices for your data collection.
4. Construct a data table to collect data during the next month.
5. At the end of the month evaluate your data. Is your ecosystem balanced or not? (evaluation may be several paragraphs)

Discussion:

1. What are the limits of the ecosystem you build?
2. What makes a balanced ecosystem?
3. What is the role of the producer?
4. What is the role of the consumer? (consider the different levels)
5. What is the role of the decomposers?

Evaluation:

Evaluation of this investigation is based on the following

1. Definition of ecosystem
2. Data collected on ecosystem for one month
3. Evaluation of ecosystem built by student
4. Discussion questions

For further investigation:

If you determined your ecosystem is balanced, what could you add to upset the balance? See if you are correct by continuing for an additional two week period.

If you determined your ecosystem to be unbalanced, what do you need to do to balance it? See if you can correct the imbalance and continue for another two weeks.

References:

Odum, E. P. *Fundamentals of Ecology;* Holt, Rinehart & Winston, New York, 1963

INVESTIGATION #2

A Microecosystem

Background:

One of the major themes of ecology is the interaction of organisms with their living (biotic) and non-living (abiotic) environment. The interaction of the organism with both factors is essential for the survival of the organism. Changes in the biotic or abiotic factors can cause serious problems for the survival of the organism. The other consequence of changes could be an increase in the size of the population until one organism is the dominant species. It could also lead to over-population which might threaten the survival of the species.

In this investigation, we will be making a mini or microecosystem. The biotic and abiotic factors will be randomly introduced. You will be asked to follow the natural progression of the microecosystem observing to the greatest detail possible.

Objectives:

1. Student will become familiar with the relationship of living organisms with the other living and non-living factors of an ecosystem.
2. Student can compare the microecosystem with the larger ecosystem constructed in the previous investigation.

Materials:

microscope	transparent wrap
microscope slides	test tubes or small jar
cover slips	dried grass, leaves, soil, or hay
droppers	pond water

Procedure:

1. Fill a test tube or jar with a small amount of leaves, grass, hay and/or soil.
2. Add pond water. (enough to come within 1cm of the top)
3. Observe one drop of the culture under the microscope. You may not see much the first or second time. It may take careful scanning of the slide to find living organisms. Make observations on what you see. If possible, use a "key" and try to identify what you see.
4. When you are finished with your observations for the day, cover with transparent wrap and place on the window sill.
5. Twice a week for the next few weeks make observations on the microecosystem. Observations should be macroscopic as well as microscopic. Odor, color and clearness should be noted.
6. Compare what is happening in your microecosystem to the larger ecosystem you build.

Evaluation:

1. What is the relationship of the abiotic to the biotic environment?
2. List as many similarities and differences as you can for the two ecosystems you have been observing.

References:

Andrews, W. A., *A Guide to Freshwater Ecology;* Prentice Hall Inc., Englewood Cliffs, N. J., 1972

INVESTIGATION #3

Algae — Man's Best Friend

Background:

Some people say dogs are man's best friend. Others suggest that maybe our true friends are the algae in the lakes, streams, and the oceans. Algae are among the smallest plants, but they also have some of the fastest rates of photosynthesis in the plant kingdom. The process of photosynthesis takes carbon dioxide and changes it into carbohydrates with the help of the sun as the source of energy. In the process of photosynthesis, water is split and oxygen is produced. Oxygen is a by-product of photosynthesis, but it is extremely important to us as well as other animals and plants. The algae of the ocean are said to produce 75% of all the oxygen in our atmosphere. Some estimates go as high as 95%. We are dependent on these tiny plants for our survival.

We must also not forget that the algae are the beginning of the food chain for many aquatic and marine organisms as well as man. Photosynthetic organisms are the only forms of life which have the ability to take sunlight and change it into chemical energy usable by animals.

In this experiment we are going to measure the amount of oxygen produced from an algae culture during photosynthesis. We will also try to prove that the gas being evolved is oxygen.

Objectives:

1. Student can correctly measure the amount of oxygen produced by photosynthesis of an algae culture.

2. Student can prove by glowing splint test that the gas evolved from the algae culture during photosynthesis is oxygen.

Materials:

large test tube
plant fertilizer
sodium bicarbonate
algae culture (stock)
light source
Hach Kit for dissolved oxygen test
gas collecting bottle
woodsplint

Procedure:

1. This is a long term experiment which may take up to one month to complete. The first step is to establish an algae culture for your lab team. This is easily done by taking about 100ml stock algae culture and adding it to 400ml of distilled water which has fertilizer added. (Check fertilizer container for proper concentration.)
2. After you have a healthy culture of algae you can start your experiment. Fill a large test tube with algae culture. Place it in the dark overnight. The next day, determine the dissolved oxygen concentration using the Hach Kit. Record it in your data table. Add 5ml of 1.OM $NaHCO_3$ solution to the algae culture. Cover the culture with plastic wrap and place in the growing room or under artificial light for 60 minutes.
3. After 60 minutes remove the culture quickly from the light. Determine the dissolved oxygen concentration using the Hach Kit. To determine the amount of oxygen produced subtract the initial D.O. from the final D.O.
4. The second part of this investigation is to prove that the gas given off is oxygen. Fill a 250ml Erlenmeyer flask with algae culture. Add one gram of $NaHCO_3$ and some solid fertilizer. (Check the fertilizer container for correct concentration.) Connect the flask to a gas collecting test tube as shown below.

light
algae
fertilizer
$NaHCO_3$
small test tube
collecting tray filled with water

5. Place the set-up in strong light, natural or artificial "Growlux". Collect gas until the test tube is full. (This may take one to two days.)
6. Remove the test tube from the gas collecting tray quickly placing a glass slide over the mouth to prevent the gas from escaping. Obtain a wooden splint. Start the splint burning and then blow it out so it is still glowing. Quickly plunge the glowing splint into the test tube and observe the reaction.

Evaluation:

1. Give the correct equation for photosynthesis.
2. Why are algae so important to life on earth?
3. Why did we add sodium bicarbonate to the culture before placing it in the light?
4. In step three, are we determining all the oxygen produced by photosynthesis? What other factor should be considered?
5. What was the reaction of the glowing splint when it was placed into the tube of gas you collected? What does this mean?

INVESTIGATION #4

Liebig's Law of the Minimum

Background:

Phosphorus (P) and nitrogen (N) are necessary nutrients for the growth of any aquatic plant life. The production of carbohydrates, through the process of photosynthesis, does not itself satisfy the needs of the plant cell. Various fats and proteins must be formed from carbohydrates to furnish the additional compounds necessary for life. Phosphorus and nitrogen enable this to take place. But, if either of these nutrients is in short supply, it becomes a limiting factor, retarding further growth. In chemistry, it is stated that when the reagent in minimum supply has been used up, the reaction must end. This is known as Liebig's Law of the Minimum.

Objectives:

1. Students can adequately demonstrate Liebig's Law of the Minimum.
2. Student can adequately explain his/her understanding of Liebig's Law of Minimum.

Materials:

7 water bottles (gas collecting bottles)	algae culture
teaspoon	liquid plant fertilizer
tablespoon	distilled water
dropper	½" piece of chalk
	plastic wrap

Procedure:

1. Set up seven bottles each containing a ½ inch piece of chalk and ten drops of algae suspension.
2. Fill the first bottle with liquid fertilizer, and to the others add 5 tablespoons, 1 tablespoon, 1 teaspoon, 20 drops, 2 drops, and none consecutively. Then fill the last six bottles with distilled water.
3. Place plastic wrap over each bottle and place in the sun light.
4. This is a long term experiment that should be observed at 2 or 3 day intervals for a period of one month. Check the growth of scum. You might want to make a chart for recording observations. Rate of growth is what you are to look for.
5. At the end of the first week tie a string around a microscope slide. The slide can be dangled in the bottle and examined under the microscope weekly.
6. Rotate the bottle 180° during the week. This will insure even growth. This nullifies the effects of shading.

Questions:

1. How does the quantity of liquid fertilizer relate to Liebig's Law of the Minimum?
2. Why might the growth of algae on the sides of the container be different from the growth on the microscope slide?
3. Did you notice any effects of shading? If so, what?
4. What is the role of the chalk?

Evaluation:

1. Laboratory write up
2. Questions
3. Quiz

INVESTIGATION #5

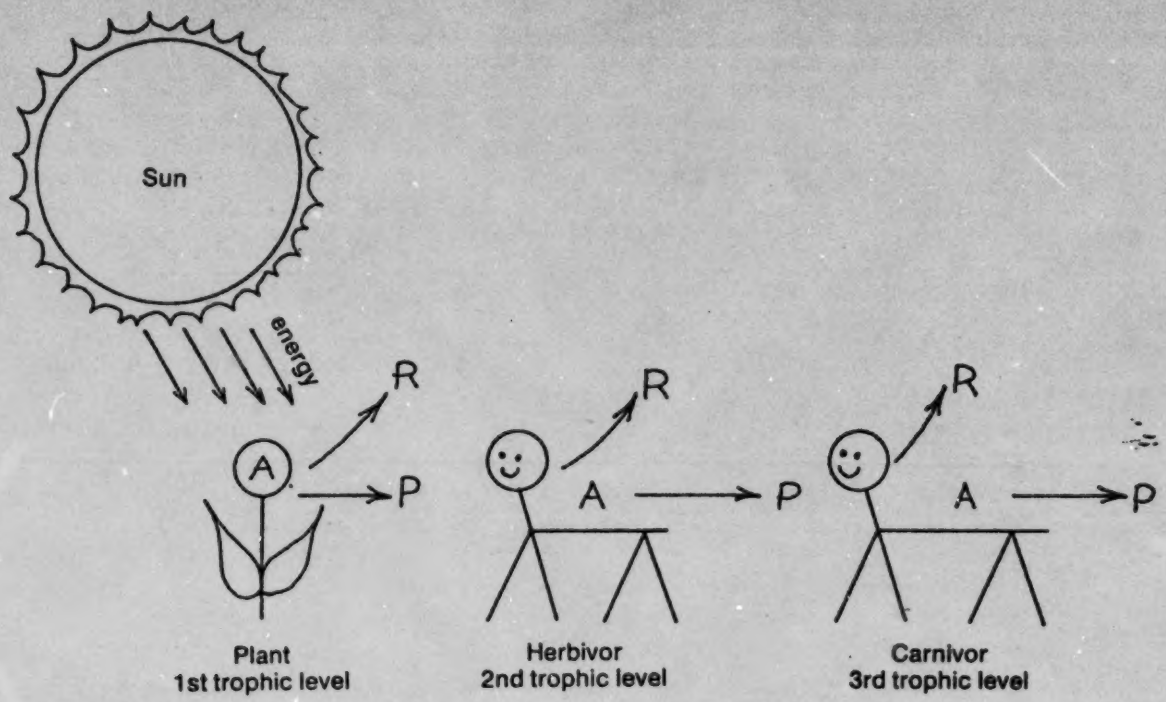
Food Webs

Background:

Food webs or food chains describe the transfer of food energy from the source in plants through a series of organisms with repeated eating and being eaten. There are two basic types of food chains: the grazing food chain which starts with green plants, goes to grazing herbivors and on to various carnivors; and the detritus food chain which goes from dead organic matter to microorganisms and then to detritus feeders and their predators. Food chains are not as simple as the term implies but as interlocking and interconnecting. For this reason we often refer to them as food webs rather than food chains.

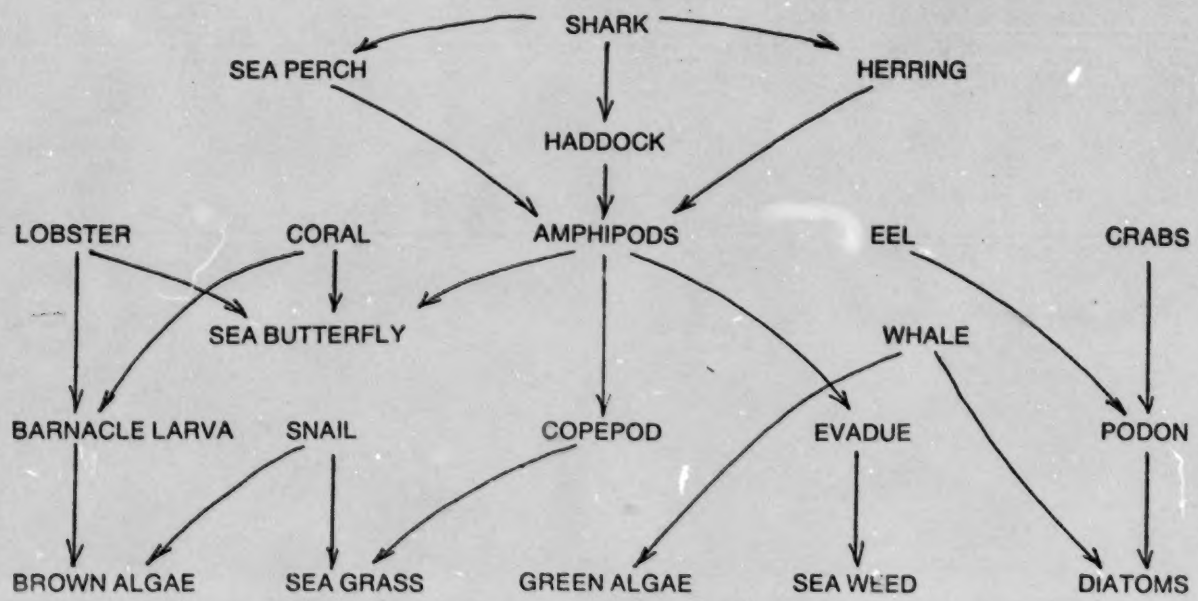
In complex natural communities, organisms occupy different trophic levels. Green plants (the producing level) occupy the first trophic level. The herbivors (plant eaters) are referred to as primary consumers and occupy the second trophic level. Carnivors (flesh eaters) who eat the herbivors are in the third trophic level. The trophic levels can continue as long as the chain or web continues. Man is often the upper limits of the trophic levels since we have no natural predators.

It is possible to make an energy diagram illustrating the flow of energy through the ecosystem. (A) represents total energy assimilation, (P) represents the productivity or biomass at that level, and (R) represents the respiration used during productivity.



It should be noticed, that as the trophic level gets higher, the amount of the original productivity (P) gets smaller. The food web looses great amounts of energy as it passes from one trophic level to the next.

The following is an example of a food web which might be found in the ocean. This particular example contains five trophic levels with the shark at the fifth trophic level.



This is but one example of a food web. Every ecosystem has its own food web. For more information about food webs see the following reference books:

Odum — *Fundamentals of Ecology* (Chapter 6, pp.37–84)
Smith — *Ecology and Field Ecology*

Objectives:

1. Student is able to correctly construct an example of a food web listing producers and consumers.
2. Student is able to correctly define the following terms, which are related to food webs or chains:
   a. producer
   b. primary producer
   c. consumer
   d. herbivor
   e. carnivor
   f. biomass
   g. trophic level
   h. assimilation
3. Student is able to correctly construct a food web which was observed at the Outdoor Education Center showing a minimum of 2 producers and 5 consumers.

Materials:

1. hand lens or dissecting microscope
2. pencil and paper
3. Reference books — Odum — *Fundamentals of Ecology*
   Smith — *Ecology and Field Ecology*

Procedure:

1. Go to one of the reference books listed, or another ecology text in the library. Read the chapter related to food webs and energy. Construct a hypothetical food web (one not given in the reference book).
2. Define the following terms:
   a. producer
   b. primary producer
   c. consumer
   d. herbivor
   e. carnivor
   f. biomass
   g. trophic level
   h. assimilation
3. Go to the Outdoor Education Center. Find a temporary pond (puddle), or go to Bates Pond. Construct a food web which you observe. Classify the trophic levels.
4. Again at the Outdoor Education Center observe a particular terrestrial environment. Construct a food web which you observe. Classify the different trophic levels. Remember nature did not read this investigation, observation may be difficult and time consuming.

Questions:

1. List the components of a food web. Describe the function of each.
2. Why is a food web so complex?
3. Why is a food web more accurate than a food chain?
4. Which component of a food web is most important? Why?

Evaluation:

1. Quiz on terms
2. Construction of aquatic and terrestrial food webs
3. Discussion questions

For further investigation:

1. DDT in the food web of the Bald Eagle
2. Mercury in the food chain of fish in Lake Erie
3. PCB in the food chain of man

References:

Odum, E. P., *Fundamentals of Ecology;* Holt, Rinehart, & Winston, New York, 1963.
Smith, R. L., *Ecology and Field Biology;* Harper & Row, New York, 1966.

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INVESTIGATION #6

Biological Clocks (Periodicity)

Background:

There is a season for everything
And a time for every purpose under the heaven:
A time to be born, and a time to die;
A time to plant and a time to reap.

Ecclesiastes

Introduction:

— TIME

In a sense, every living thing is a time mechanism. Inevitably, it must run down with time, age and die. To survive, even for a while, it must keep time with itself and its surroundings. Its cells and organs must do the right thing not only in the right place, but also at the right time. A plant that grows leaves before it develops roots will quickly wither; an animal whose heartbeat fails to keep pace with its activity will perish.

Heat and humidity, food resources and enemies, all change as day follows night and summer follows winter. To avoid extinction, plants and animals must at the very least adapt to these external time cycles. In fact, nearly all organisms have evolved mechanisms, "biological clocks", which allow them to anticipate the cycles. These mechanisms determine when plants flower and when birds fly south. They also govern the sleeping and waking cycles of man.

There seems to be two basic elements: The first is the clock, which regulates processes within the organism. The second is the "synchronizer," or timer, which links the processes to a point in the clock's daily cycle — much as we set the hands of a watch to any hour we choose without disturbing the motions of the gears within. The synchronizer is invariably an external influence — usually light, but sometimes temperature. The clock itself, in the opinion of nearly all investigators, lies within the plant.

Objectives:

1. To write correct definitions for terms pertaining to biological clocks.
2. To correctly compare internal synchronization of an organism with its external synchronization, specifically light.
3. To study in some detail one of the following as it pertains to biological clocks:
   a. bird migrations — Ex. Pacific Golden Plover
   b. hibernation — Ex. Chipmunk
   c. bees
   d. plants
   e. man
4. To investigate Dr. Hudson Hoagland's physiochemical hypothesis that time could be a variable experience (optional)
5. To observe a paramecium reproducing in a wet mount as well as prepared slides

Materials:

In field:
notebooks and pencils; bird books; binoculars and thermometers
In lab:
jar of actively dividing paramecium
15 sturdy common bean plants with petioles and leaves
black boxes constructed to cover the bean plants completely
compound microscopes
dropping pipettes
glass slides and cover slips
5.0% methyl cellulose solution
Lugol's solution
cotton
1.0% methyl green solution
toothpicks
prepared slides of dividing and conjugating paramecia

Procedure:

This investigation in the field will depend on the availability of certain organisms. Taking students to the Outdoor Education Center to look for bees, chicory, clover, birds, and ants might take one class period. Observing the activities of these plants and animals might consume another period, but this is the only way that the student can actually see biological clocks "ticking".

1. Part A: Activities in the field

Divide the students into groups, some to find and observe bees; others to locate chicory plants; others to observe various birds, and some to look for ants and ant hills. Record all observational data.

Take a second class period to make similar observations, keeping the same student groups; record all data.

Group Procedures:

Bees or Ants

a. Where did you locate the bees or ants?
b. How many did you find?
c. What were they doing as you observed them at different time intervals?
d. Record the time, temperature, and weather conditions when your observations were made.
e. Could you follow the bees or ants?

f. What did you notice about their behavior?
g. List any differences you noted when you observed the bees or ants a second time.

Chicory

a. Where did you find the chicory plant? Describe the texture of the soil in that location.
b. Describe the blossom of the plant.
c. Record the time, temperature, and weather conditions when your observations were made.
d. Observe the petals of the blossom on a second occasion at a different time of day. Note any differences. Can you explain these differences?

Birds

a. Keep a record of how many and what kinds of birds you see at the Outdoor Education Center during one class period.
b. Record the time, temperature, and weather conditions at the time of your observations.
c. Record the activity of each bird sighted. Identify the tree or shrub on which it is perched.
d. Graph the number of song sparrow songs heard per minute at selected times of the day.
e. On the second field day, keep a similar record to the first day. Compare the data.

2. Part B:

Activities in the laboratory

a. Set up a captive ant colony as shown below.

Ant Colony
Food with dye
Changeable Paper

Observe the eating habits of ants time-wise. Ants will tramp the dye around on the paper tubing. Change the paper every two hours and compare the samples for dye.

b. Construct a light box for transplanted chicory or clover plants. Observe the circadian cycle demonstrated by the opening and closing of the flower blossoms. Account for this.
c. *A microscopic timekeeper*: The one celled paramecium reproduces on a regular schedule by dividing itself into two new cells. The splitting process takes 20 minutes and usually occurs five times a day, depending on conditions of light and temperature. Observe the dividing paramecia. Vary the light. Vary the temperature.
d. Using an onion with actively growing roots, determine when mitosis occurs by making root smears.

3. Part C:

Activities in the resource center

Some of the students can be researching the topic of biological clocks in bird migrations (Pacific Golden Plover or a bird indigenous to Ohio), hibernation (ground squirrel), social insects, (bees) plants and man while others are working in the laboratory (Part B). On a second day, the students can exchange places in the library and the laboratory.

4. References for resource center research

a. Claiborne, Robert and Editors of Life, *Life Science Library;* Time Incorporated, New York, 1966.
b. Johnson, et. al., *Biology*; Holt, Rinehart and Winston, Inc., New York, 1966.
c. Luce, G. G., *Body Time*; Patheon Books, New York, 1971.
d. Luce, G. G., *Biological Rhythms in Human and animal Physiology*; Dover Publications, Inc., New York, 1971.
e. *Science Digest*; May, 1974, pp. 6 & 26.
f. *The Courier*; "What Ducks Have Taught Us About Biological Clocks"; UNESCO, January, 1974. pp. 36–39.

5. One student from each group share their observations from the field study. Another share observations from the laboratory work, and a third share the research information from the resource center. Open discussion should follow the reports.

Evaluation:

1. Teacher evaluation from oral participation by the students, as well as written papers on the topic "Biological Clocks"
2. Quiz on the following terms: circadian, periodicity, biological clock, and rhythm
3. Quiz questions:
   a. What role does timekeeping play at the simplest level of life — the single cell? At the most complex level of life — man? Discuss the role of the pacemaker in man's heart.
   b. What is the importance of understanding biological clocks to the commercial flower grower? Give some examples.

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Further Inquiry:

1. Study and report on the migration of the Pacific golden plover, starlings, and the whitethroat warblers.
2. Study and report on the direction-finding capacity of bees.
3. Study and report on the mammal's master clock. Ex. female rats.
4. Study and report on the effect of the rise and fall of the tides on sea anemones, beach worms and the New England fiddler crab.
5. Study and report on the Canadian snowshoe rabbit's growth of its white winter fur.
6. Study and report on insect hibernation.
7. Observe a community of ants to determine whether they eat according to a fixed time schedule.
8. Investigate "Artic Winter Madness". Summarize how our human cycles are synchronized with those of Earth.

INVESTIGATION #7

Development of a Successful Plot and Related Activities

Background:

As the interaction between organisms and their environment shifts, ecological successions occur. This idea of interactions among living and nonliving things leads to looking at a community as one step in a sequence of events (succession) leading to a more slowly changing community (climax). Therefore, "succession is the process by which ecosystems in an area move toward the climax ecosystem — the one determined by climate."

Objectives:

1. To correctly identify ways in which environmental factors interact to set limits to naturally occurring organisms
2. To demonstrate in the laboratory the interaction between the living organisms and their nonliving environment
3. To develop several successional plots at the Outdoor Education Center
4. To write an assignment demonstrating knowledge learned about succession

Materials:

Instamatic camera and film
small jars with pond water
notebook or clipboard
test tube racks
spade
small water snails
meter stick
elodea
8 screw-cap culture tubes
paraffin for sealing

Procedure:

1. Dig up a small plot of ground 1 m2 at the Outdoor Education Center. Keep a record at regular intervals to show the reappearance and growth of organisms. Describe the characteristics of the climate (Ex. the soil, the wind, and the moisture in the area).
2. Look for a bare rock or fallen log. Take a photograph of the spot and at regular intervals describe the changes which you can observe different from the original photograph.
3. In the laboratory, prepare a sealed test tube containing pond water and a snail. Seal a tube containing a green aquarium plant and pond water. Put a snail and green plant in pond water and seal the tube. Predict how long the snail will live; the green plant; the plant and the snail. (Some students should choose #3, while others should work on #4.)

— Do some research to explain what forces may alter the interaction among organisms in the test tubes. How may changes in physical conditions affect life in a pond? (Check the oxygen-carbon dioxide cycle, nitrogen cycle, mineral cycle, energy cycle, and the notion of a pyramid of producers and consumers.)

4. Changes in the chlorella mini-ecosystem may be observed within a class period or during the course of several days. Obtain a supply of the green alga, Chlorella. (There is a wide selection of research literature available on Chlorella.)
   a. What is the average rate of reproduction of Chlorella? Isolate a small number of cells in a microaquarium; make daily counts of the cells.
   b. What are the effects of adding additional quantities of minerals such as nitrates, magnesium, or phosphates on growth and physiology?
   c. What is the effect of additional amounts of carbon dioxide on Chlorella?
   d. Does Chlorella affect the pH of its environment? If so, does this affect the succession of other micro-organisms in the habitat?
   e. Is the usual biological succession of organisms affected in the microaquarium by increasing the intensity of light? Decrease the light. Could such alterations in the environment affect the survival of Chlorella?

Evaluation:

1. Written assignments to be discussed and evaluated. Possible topics are:
   a. Describe the characteristics of a successional ecosystem in your own biome.
   b. Explain the effects of fire on succession in at least two ecosystems.
   c. Explain man's effects on ecosystems in terms of succession.

References:

1. Brandwein, Morholt and Joseph, *A Sourcebook for the Biological Sciences*; Harcourt, Brace and World, Inc., New York, 1966.
2. Smith, Robert L., *Ecology and Field Biology;* Harper and Row, New York, 1966.

Supporting films:

1. "From Sand Dune to Forest"....EBF.....16 min.
2. "Succession on Lava".....EBF.....14 min.

INVESTIGATION #8a

Hydrologic Cycle

Background:

Water moves continually through a cycle from the atmosphere to the earth, through and over the earth and then back into the atmosphere. This cyclic movement of water is called the hydrologic cycle. As the water moves from the atmosphere, through and over the earth the quality of the water changes. Changes in the water quality are caused by geology of the land, man's use of the land, the amount of water falling, and the substances added to the water by man and nature.

Figure 1 illustrates the hydrologic cycle showing many of the different pathways water can take in its cycle.

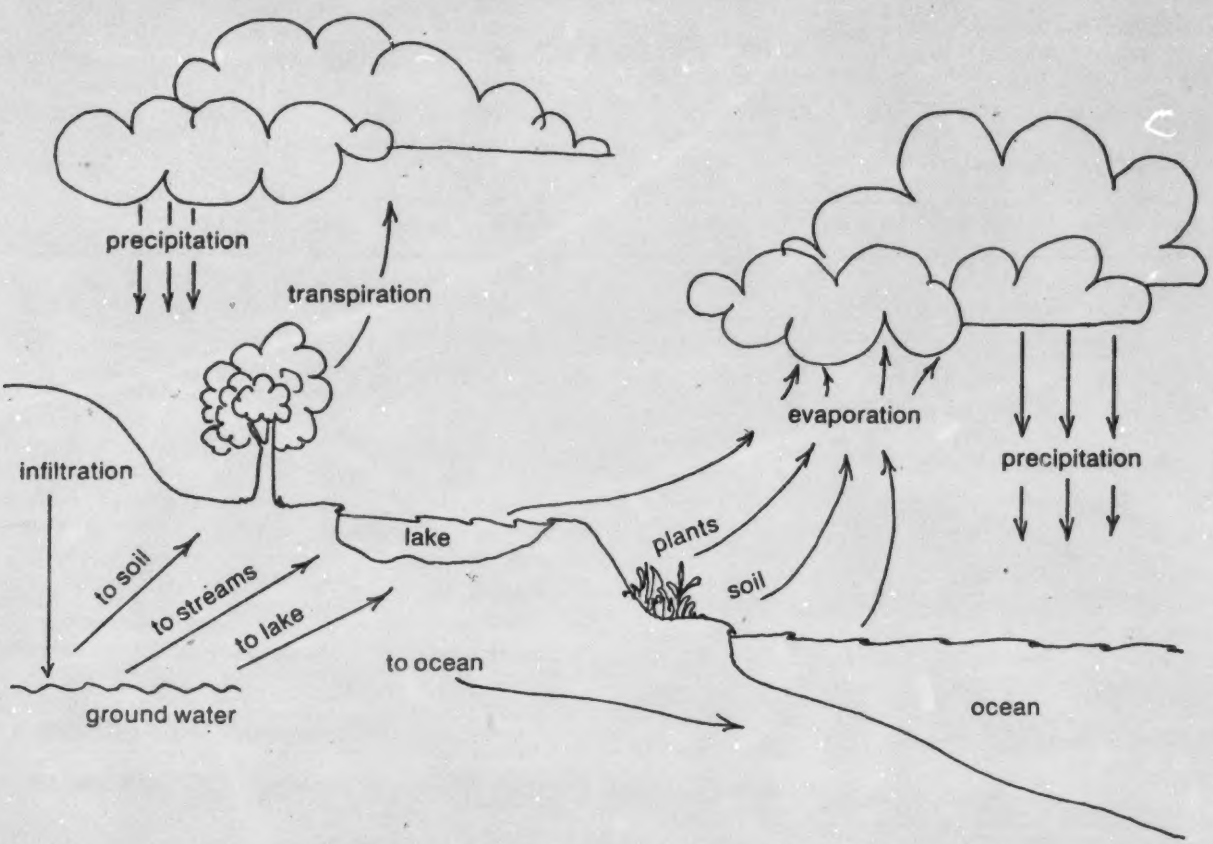

Figure 1 Hydrologic Cycle — Modified from Smith, 1966

The flow of water is made up of many small cycles. Rain water can run off into lakes and streams which can find their way to the ocean or evaporate. Some of the rain filters down through the soil and becomes part of the gound water or the water tables. Water can surface through springs or be brought to the surface by wells. Plant roots can also draw water from the soil.

Transpiration is the giving up of water from plants to the atmosphere by evaporation. It is an essential function in plants to keep them cool. Animals also are in the hydrologic cycle and need water for respiration, cooling and excretion.

As water travels through the cycle the quality of the water changes. Run-off usually contains large amounts of suspended solids. Water which has filtered through the layers of rocks often is very pure, yet may contain many dissolved solids or minerals. Man and animals are known to add many different types of substances to water in lakes and streams. Most of the substances found in water are lost as it evaporates back into the atmosphere.

Objectives:

1. Students can correctly draw the hydrologic cycle.
2. Students can correctly measure rainfall during a 24 hour period.
3. Students can correctly describe the effects of slope on surface run off.
4. Students can correctly describe the effects of vegetation on surface run-off.

Materials:

small shovel — graduated cylinder
tray, or pan — rain gauge
#10 can with holes in the bottom
U.S. Weather Service records

Procedure:

1. In this investigation you will need to find several different areas for study. You may go to the Outdoor Education Center, the school yard, or at your home. The different areas should include: a) hard pack surface, no vegetation, gradual slope; b) hard pack surface, some vegetation, gradual slope; c) grass covered slope; d) tree covered slope.
2. At each of the above areas, dig a hole in which to place the pan or tray. On the slope above the tray simulate rain using the #10 can and a known quantity of water. (1 liter) See figure 2
3. Collect the surface run-off in the tray and accurately measure the amount collected.
4. Make a table and record the data collected at the different sites. Compare the data collected and try to make a comparison of the four different sites.

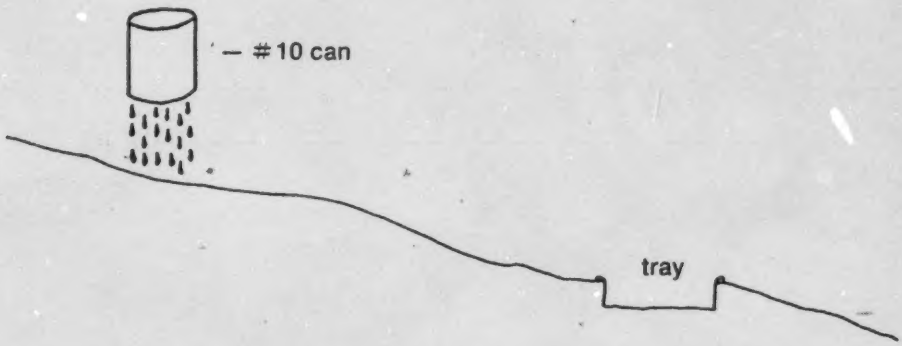

Figure 2

5. Each lab group will be asked to collect rainfall data which will be kept for a two week period. Instruction will be given for use of the rain gauge. Check with your instructor for the day you are responsible for collecting data and place your data on the master data chart. When possible, compare the collected data to last year's rainfall for the given dates.

Questions:

1. What is the average rainfall in Rocky River? Was our data above or below the average? Why?
2. What is the effect of slope on surface run-off?
3. What is the effect of vegetation on surface run-off?

Evaluation:

1. Data collected and comparison in run-off experiment.
2. Evaluation of rainfall data.

References:

A Curriculum Activity Guide to Water Pollution and Environmental Studies; Institute for Environmental Education, Cleveland, Ohio

INVESTIGATION #8b

Hydrologic Cycle

Background:

See Investigation 12

Objectives:

1. Students can accurately demonstrate the movement of water in different types of soil.

Materials:

shovel
aluminum fence
bucket
meter stick
graduated cylinder
#10 can with holes in bottom

Procedure:

1. Select several different areas. Try to select flat ones with different types of soil (clay, sand, loam). You may need to construct the sandy area.
2. Carefully remove vegetation from an area 50 cm in diameter and place an aluminum fence around the cleared region. Dig five small holes about 10 cm deep, 10 cm from the edge of the fence.
3. Using the #10 can, simulate rainfall with 1 liter of water in the center of the circle; rain should fall inside the aluminum fence.
4. Using a stop watch, measure the time it takes for water to appear in each of the holes around the fence and record the data on a data table. If water does not appear in 15 minutes, add an additional 500 ml of water.
5. Optional: If time permits you might try areas with different types of vegetation.

Evaluation:

1. What type of soil permits the fastest filtration? The slowest?
2. Describe the movement of water when it moves through the soil.
3. What other conditions could affect the rate of filtration and absorption?

References:

A Curriculum Activity Guide to Water Pollution and Environmental Studies, Institute for Environmental Education, Cleveland, Ohio.

INVESTIGATION #8c

Determination of a Watershed

Background:

A watershed, as defined by Webster's dictionary, is "a region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water". What this actually means is that every river, stream, or lake has its own watershed. The larger the stream or river the larger the watershed. Small stream watersheds may be a part of a larger river watershed and so on. In this investigation you will be learning to read U. S. Geological Survey maps. They have much information on them including area use designation. This can be very useful when making a river or stream study. The maps also have latitude and longitude on them so as an investigator you can accurately locate a research station at which you are working. For more information on watersheds of rivers and streams see the following references:

Reid, George, *Ecology of Inland Waters and Estuaries*; Van Nostrand-Reinhold Company, New York, 1961.

Objectives:

1. Students are able to correctly read a U. S. Geological Survey Map.
2. Students can correctly determine the latitude and longitude of a particular site of a river or stream.
3. Student can correctly determine the watershed of a river or stream.

Materials:

magic marker
U. S. G. S. map
centimeter rule
plastic transparencies

Procedure:

1. On a U. S. G. S. map of Ohio, locate the stream or river under study.
2. Determine the latitude, longitude, the source and the mouth of the river under study.
3. Choose the U. S. G. S. 15´ quadrant map for your study area. This may include more than one map.
4. Determine the drainage area (watershed) which supplies the river or stream. Calculate the area in km^2. It may be necessary to convert English to metric measurement. Using a clear plastic sheet and a magic marker, outline the area enclosed in the watershed.

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5. Using the legend on the map, estimate the percent of farm land, forest, developed areas (buildings) and roads within the watershed area calculated above.

Evaluation:

1. What factors affect the size of the watershed for a river or stream?
2. How does the development of the watershed affect the river?
3. Try to determine from the map where the greatest erosion problems are within the watershed. Why do you feel it is the area you choose?

Reference:

Reid, George, *Ecology of Inland Waters and Estuaries*; Van Nostrand-Reinhold Corp., New York, 1961.

INVESTIGATION #9

Determination of Stream Parameters

Background:

Running water is constantly modifying the stream or channel it follows. At best the only parameters which one can measure are those which exist at the present time and at the location being studied. Many of the parameters which we will study such as stream flow, depth, and width, are directly related to the water table and the amount of precipitation of the past few hours or days.

Objectives:

1. Student can correctly determine the basic stream parameters such as depth, width, and stream flow.

Materials:

tape measure	ping pong ball
meter stick	hip boots
stopwatch	data collection sheet

Procedure:

Part I. — Average depth, maximum depth

1. The depth of a stream usually refers to the maximum depth within the segment of stream being studied. Carefully walk across the stream. Use a long stick to probe for holes so you don't get in over your boots. When you find the deepest point, measure it with a meter stick and record this on your data sheet.
2. The average depth of the stream is found by measuring at least five different locations across the stream in a straight line. Record each of the depths, add them together and divide by five to get the average depth. Record the average depth on your data sheet.

Part II. — Average width

1. To find the average width at the station or site being studied, it is again necessary to make several measurements of the width of the stream. The three measurements should be within 30 meters of your sampling site.
2. Take three or more measurements of the width of the stream. Use a long tape measure if one is available, or use a string and then measure the string. To find the average width, total the measurements and divide by the number of measurements taken. Record the average width on your data sheet.

Part III. — Stream Flow

1. Measure and mark a 50 meter distance along a section of the stream near the site you are studying.
2. With one person standing at the upstream point, release a ping pong ball in the middle of the river.
3. On the signal from the upstream person, the second person will start a stopwatch as the ball is released. The downstream person will stop the watch as the ball passes the 50 meter mark.
4. Calculate the rate of flow in meters per second.

50 meters ÷ _____ = _____ meters/sec.
(#'s or Secs.)

5. Repeat the above procedure three times and average the rate of flow. Record the average on your data table.
6. In the above steps you have found how fast the water is moving. This is not meaningful unless you find how many cubic meters of water are flowing during a particular time. To calculate the flow in cubic meters the following procedure is followed. Multiply the average width, times the average depth, times the flow in meters per second. This equals the flow in cubic meters of water per second.

Evaluation:

1. Why are the measurements you take today going to be different from the ones you take tomorrow or six weeks from now?
2. What are the different factors which affect the average depth, average width and stream flow?

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3. If a city is to use the river for a water supply, what are the critical factors which they must consider?

For further investigation:

1. Calculate the size of a city or town the river you studied can support. Include water use and waste disposal.

References:

Reid, George, *Ecology of Inland Waters and Estuaries*; Van Nostrand-Reinhold Corp., New York, 1961.

INVESTIGATION #10

Determination of the Chemical Nature of a Stream

Background:

The chemical analysis of a river or stream can only give you the composition of the water at the time the test is being made. If toxic discharges are added only periodically, it may be difficult to determine. However, chemical analysis of a stream or river is a useful tool in the overall determination of water quality.

To analyze data collected you need to compare your results with the standard established for the river or stream. There are handbooks which give this information and you will need to check them as a reference.

Several of the most important chemical tests include dissolved oxygen, pH and temperature. The following charts may help in analysis of your data.

pH Ranges Tolerated by Various Aquatic Life

	pH Range	
Plants algae and rooted	6.5	12.0
Carp, suckers, catfish some insects	6.0	9.0
Bass, crappies	6.5	8.5
Snails, clams and mussels	7.0	9.0
Largest variety of animals Stoneflys & caddis fly	6.5	7.5

Approximate Temperature Range Required for Growth of Certain Organisms

Organism	Temperature
Much plant life, most fish diseases, most bass, crappies, bluegill, carp, catfish, caddis fly	Greater than 68°F
Some plant life, few fish diseases, salmon, trout, stone fly, may fly, caddis fly, water beetles, striders	55°F—68°F
Trout, caddis fly, stone fly, may fly	Below 55°F

Dissolved Oxygen Requirements for Native Fish & Other Aquatic Life

	D. O. in ppm
Cold water organisms, (below 68°F) (trout and salmon) spawning	7.0 or above
Growth and well-being of cold water organisms	6.0 or above
Warm water organisms including game fish such as bass, crappie (above 68°F)	6.0 or above
Growth & well-being of warm water organisms	5.0 or above
Most insects, carp and suckers, catfish	3.0 or above
Low-oxygen insects (pollution tolerant species)	.05 or above

Objectives:

1. To determine the chemical composition of a stream using standard chemical tests
2. To compare the results of the chemical analysis with the U. S. Drinking Water Standards or those standards which apply to the designated use of the river or stream.
3. To determine what chemical factor might be affecting the quality of aquatic life of the stream.

Materials:

Chemical Field Test Kit (Hach Co.)
data sheet
U. S. Public Health Service Drinking Water Standards
Standards for various Water Quality Criteria for use
Classification

Procedure:

1. Using the Hach Kit (instructions in lid), perform the following chemical test at the river site.
   a. dissolved carbon dioxide
   b. pH

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c. dissolved oxygen
d. temperature (air and water)
e. Hydrogen sulfide (optional)

Record results of each on your data sheet. (These must be performed at the site to have accurate results)

2. Using the Hach Kit (instructions in lid), perform the following chemical test at the site or take a 2 liter sample in a clear jar or bottle to be tested back in the laboratory.
   a. alkalinity
   b. chloride
   c. chromium (optional)
   d. color
   e. fluoride
   f. hardness
      calcium
      magnesium
      total
   g. iron
   h. manganese (optional)
   i. nitrogen
      nitrite
      nitrate
   j. phosphate
      ortho
      meta
      total
   k. silica (optional)
   l. sulfate
   m. turbidity

   Record your results on the data sheet

Evaluation:

1. What chemical factors do not meet U. S. Drinking Water Standards? What other information do you need to know if the water is drinkable?
2. What factor may be limiting the quality of aquatic life in the stream?
3. What was the Dissolved Oxygen? What type of organism would you expect to find in this stream?
4. Are your results different from another group? If they are different, why?
5. Could you expect different results one week from now? Why? What conditions would affect your results?
6. What can you say about the water quality of this stream?

CHEMICAL DATA

River or Stream _____

Station and Location _____ Date _____

Methods _____ Units _____

Alkalinity:		Manganese	
Phenol		Nitrogen:	
Total		Nitrite	
Carbon dioxide		Nitrate	
Chloride		Oxygen	
Chromium		Phosphates:	
Color		Ortho	
Fluoride		Meta	
Hardness:		Total	
Calcium		Silica	
Magnesium		Sulfate	
Total		Turbidity	
Hydrogen sulfide		pH	
Iron		Odor	
Remarks:		Temperature:	
		Water	
		Air	

Laboratory Analyst: _____

U. S. Public Health Service Drinking Water Standards

Characteristic	Limit Not to be Exceeded
Physical	
Color	15 units
Taste	Unobjectionable
Threshold odor number	3
Turbidity	5 units
Chemical	mg/1
Alkyl benzene sulfonate	0.5
Arsenic	0.01
Barium	
Cadmium	
Chloride	250
Chromium (hexavalent)	
Copper	1.0
Carbon Chloroform extract*	0.2
Cynaide	0.01
Fluoride	0.6–1.7
Iron	0.3
Lead	
Manganese	0.05
Nitrate	45.0
Phenols	0.001
Selenium	
Silver	
Sulfate	250
Total dissolved solids	500
Zinc	5.0

*Organic contaminants

Tolerance Index for Benthic Macroinvertebrates

I—Intolerant:

Organisms that are not found associated with moderate levels of organic contaminants and generally intolerant of even moderate reductions on dissolved 0_2

F—Facultative:

Organisms that have a wide range of tolerances and frequently associated with moderate levels of organic pollution

T-Tolerant:

Organisms frequently associated with gross organic contamination and are generally capable of thriving under near anaerobic conditions

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INVESTIGATION #11

Bacteria — Bioassay as an Indication of Water Quality

Background:

Traditionally, use has been made of tests for the detection of indicator organisms rather than pathogens as indicators of polluted water. The coliform group of bacteria has been used as the principle indicator of the suitability of water for domestic, dietetic, and other uses. Specific indicators are more recently being used. These include fecal coliforms and fecal streptococci. These two bacteria are common to the intestine of warm blooded organisms. High numbers of these can indicate possible addition of raw sewage entering the river or streams.

Currently there are two methods recognized by the U. S. Public Health Service for detection of coliform bacteria. The oldest is the "Multiple-tube Fermentation Method". Results are based on the collection of gas bubbles over a 48 hour period. The second method, the "Millipore Membrane Filter Method" is faster and easier. In this method a quantity of water is passed through a filter with a pore size of .45 microns. All microorganisms larger than the pores are trapped. They are then cultured in special media and in 24 hours a direct count of coliform colonies can be made.

According to the P. H. S. standards, the sample collected must be at least 50 ml. For drinking water the arithmetic mean coliform density of all samples examined during a month may not exceed 1 per 100 ml. Coliform colonies per sample may not exceed 3/50 ml, 5/100, 7/200, or 13/500 ml in:

a. two consecutive samples
b. more than one sample when less than 20 are examined per month, or
c. in more than 5% of the samples examined per month

Objectives:

At the end of this investigation the student should be able to:

1. determine the number of coliform bacteria in a sample of water
2. determine if the water tested meets the APH standard for drinking water or drinking water supply
3. determine if untreated or partially treated sewage is entering the water tested

A. TOTAL COLIFORM

Materials:

water sample in sterile container
sterile millipore filter flask
vacuum pressure pump
laboratory incubator 37°C ± 0.2°C
plastic petri dishes
filters, type HA — grid
MF — endo broth, 2 ml ampoules
forceps
Bunsen burner or alcohol burner
sterile water

Procedure:

1. Sample Collection
   a. Sterilize a sample bottle. This can be done by autoclaving or by boiling in water for 15 minutes.
   b. Sample size is determined by the source it is taken. In most cases at least 200 ml of water is collected. It may not all be used. In general, the following quantities will be filtered:
      treated drinking water — 100–200 ml
      untreated drinking water — 50–100 ml (depending on turbidity)
      raw water — dilutions using .1, 1. and 10 ml.
2. Test Procedure
   a. Check to see all equipment is sterilized. Decide the volume of your sample to be filtered. (This depends on source)
   b. Place a sterile absorbent pad in the plastic petri dish. Add 2 ml of MF-endo media from the ampoule.
   c. Place a sterile type HA, white filter grid side up on the sterile filter flask. Use sterile forceps for the transfer of the filter.
   d. Pour the water sample into the funnel and apply the vacuum to start filtration. Do not exceed 15 psi.
   e. Rinse the funnel with 50 ml of sterile water, if less than 50 ml of sample is used.
   f. Transfer the filter to the plastic petri dish containing the sterile pad and media.
   g. Invert the dish and incubate at 35°C for 24 hours.
   h. Remove the filter from the petri dish and dry for one hour. Place the filter on a 2" x 3" microscope slide (hinge with tape) and count colonies at 10X or 15X which show a greenish metallic sheen. All organisms which exhibit the greenish metallic sheen are considered to be coliform bacteria.
   i. To determine the number of coliform bacteria in the sample use the following formula:

$$\frac{\text{Total coliform colonies}}{24 \quad 100 \text{ ml}} = \frac{\text{Coliform colonies counted X100}}{\text{ml of sample filtered}}$$

(Number of colonies per plate should not exceed 200ml)

j. Compare with the USPHS Standards
drinking water
raw water used for drinking
swimming
other

B. FECAL COLIFORM

Materials:

Same as Coliform test except those listed below
M-FC media — 2ml ampoule
Incubation — 44.5°C ± .02°C

1. Sample Collection
   a. Follow the same procedure listed for total coliform bacteria. Be sure to use sterile equipment.
2. Test Procedure
   a. Place a sterile Millipore absorbent pad in a plastic petri dish. Add 2ml of M-FC media.
   b. Filter an appropriate water sample as described in the test procedure for total coliform.
   c. Remove filter from filter funnels and place it in the petri dish on the absorbent pad.
   d. Invert the petri dish, place it in a waterproof plastic bag and incubate submerged for 24 hours at 44.5°C + 0.2°C.
   e. Examine and count all blue colonies. (Indicate fecal coliform.) Non-fecal coliform colonies are gray to cream colored.
   f. Determine the number of fecal coliform bacteria per sample.

$$\frac{\text{Fecal coliform}}{100\text{ml}} = \frac{\text{Fecal coliform counted X100}}{\text{ml of sample filtered}}$$

   g. Compare results to USPHA Standards.

C. FECAL STREPTOCOCCI

Background:

Fecal streptococci bacteria are another group which are consistently found in the intestinal tract of man and other warm blooded animals. There is some evidence that this group of bacteria may be more resistant to chlorination than other members of the coliform group.

Materials:

Same as in total coliform test except those listed below. M-Enteroccus Agar (contains triphenyltetrazolium chloride as an indicator and sodium azide as an inhibitor to non-fecal streptococci bacteria).

1. Sample Collection
   a. Same as total coliform. Be sure that equipment is sterile.
2. Test Procedure
   a. Filter an appropriate amount of water as described in total coliform test.
   b. Place filter on M-Entercoccus agar and incubate for forty-eight hours at 35°C.
   c. Examine the filter under 10X magnification. Count all red or pink colonies. These are fecal streptococcus. The red or pink is a result of the reduction of TTC.
   d. Verification is possible by placing questionable colonies into brain heart infusion broth. After growth for twenty-four hours at 35°C a catalase test is performed. Add several drops of 5% H_2O_2 to the culture. The absence of bubbles indicates a catalase - negative organism characteristic of the fecal streptococcus bacteria.
   e. Compare your results with USPHS Standards.

Reference:

Techniques for Microbiological Analysis (Millipore Corp.) Standard Methods for Water and Waste Water Analysis

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INVESTIGATION #12

Survey of Benthic Macroinvertebrates

Background:

The term benthic means bottom dweller. Macroinvertebrates means organisms which are visible with the eye and do not contain backbones.

Benthic macroinvertebrates are found in the bottoms of streams and lakes where different bottom habitats support a variety of organisms. The variety of benthic macroinvertebrates often dictates the variety of vertebrates since the benthic macroinvertebrates are usually part of their food chain. Flowing water usually has a greater variety of life than still water.

Objectives:

1. Student can sample the bottom of a stream or lake using a sampling sieve.
2. Student can correctly identify five (5) different benthic macroinvertebrates.

Materials:

Key to Fresh Water Animals — Needham and Needham
metal bucket
#30 sampling sieve
collecting bottles
white enamel pan
forceps
formaldehyde
Surber sampler

Procedure:

1. Site selection: Non-quantitative samples may be taken by sampling across a line transect set in a river, stream, or lake. If samples are for a quantitative study, a random procedure must be established for sampling. It should be remembered that macroinvertebrates communities are related to physical factors such as the substrate, current velocity, depth and salinity. Therefore, as an investigator you must select representative sites.
2. Sampling method:
   A. Non-quantitative: Sieve sampling using a metal bucket, scoop up some substrate. Wash by swirling water through the substrate, then pour the water through a U. S. Standard #30 sieve or similar device. Rewash and screen the substrate until clean. Place screenings in a jar for picking at the laboratory.
   B. Grab sample: Using an Eckman dredge or similar device, take a bottom sample. Place the sample in a jar to be picked at the laboratory.
   C. Quantitative sample:
   A quantitative sample may be taken using a Surber sampler. This presumably collects all organisms in a 1-ft. square area. The Surber sampler is placed on the bottom and a sample is collected. Place the sample in a jar and take to the laboratory for picking.
3. Preservation and sorting: The collected sample may be stored overnight in a refrigerator. Sorting can be done by placing the sample in a white enamel pan. Pick all organisms from the pan and place in 70% ethenal. Small vials may be used to separate organisms.
4. Identify a minimum of five different benthic macroinvertebrates. Identification may be aided by use of several keys.

A Guide to the Study of Freshwater Biology, Needham and Needham is a good source for reference.

INVESTIGATION #13

The Use of Benthic Macroinvertebrates as an Indicator of Water Quality

Background:

Benthic macroinvertebrates may be used as an indicator of the water quality of a river or lake. Benthic macroinvertebrates are defined as those animals that are large enough to be seen with the unaided eye, and can be retained by a U. S. Standard #30 sieve (0.595 mm opening) and live at least part of their life cycle within or upon the available substrate in a body of water.

A community of macroinvertebrates in an aquatic ecosystem is very sensitive to stress, and their characteristics serve as a useful tool for detecting environmental perturbations resulting from introduction of contaminants. Because of the mobility of benthic organisms and their relatively long life span, their characteristics are a function of the conditions in the recent past, including reactions to infrequently discharged wastes that would be difficult to detect by periodic chemical sampling.

Pollution oriented studies of benthic macroinvertebrate communities are basically of two types, quantitative or qualitative. The approach may be singly or in combination. The design of the approach is based on the purpose and the ability of the investigators.

In our study, we will primarily use a qualitative approach. However, if you would like, you may choose a quantitative type of study.

Objectives:

The student is able to make a valued judgement of water quality based on the evaluation of the benthic macroinvertebrate community.

Procedure:

1. Obtain the list of benthic macroinvertebrates collected and identified in Investigation #12.
2. Using the table of tolerances included in this investigation, give each organism a tolerance number.
   Tolerant organisms = 1
   Facultative organisms = 2
   Intolerant organisms = 3
3. Multiply the tolerance number of 1, 2, or 3 indicating the abundance for the organism.
   1 = rare (1–5 of the same organism per sample)
   = many (6 — 15 of the same organism per sample)
   3 = abundant (15 or over of the same organism per sample)
4. Add the values for all organisms in the sample and obtain a total for the sample.
5. Using the value from Step 4, an evaluation of the water quality may be made.
   0 =
toxic substance entering the water, no life present
   1–10 = poor water quality, heavy organic load, low dissolved 0_2
   11–20 = mildly polluted water, dissolved 0_2 sometimes low
   21–30 = clean water, relatively free of organic pollution

Tolerance Index for Benthic Macroinvertebrates

I - Intolerand:
Organisms that are not found associated with moderate levels of organic contaminants and generally intolerant of even moderate reductions on dissolved 02

F - Facultative:
Organisms that have a wide range of tolerances and frequently associated with moderate levels of organic pollution

T - Tolerant:
Organisms frequently associated with gross organic contamination and are generally capable of thriving under near anaerobic conditions

Table of Tolerances

Macroinvertebrates	Classification
Porifera	T
Bryozoa	F
Coelenterata	F or I
Platyhelminthes	F
Nematoda	F
Annelida	
Oligochaete	T
Tubificidae	T
Hirudinae	T
Arthropoda	
Crustacea	
Isopoda	F
Amphipoda	F
Astacidae (crayfish)	I
Insecta	
Hemiptera (true bugs)	F
Odonata (dragonflies, damselflies)	F
Plecoptera (stoneflies)	I
Ephemeroptera (mayflies)	I
Diptera (two winged flies including mosquitoes)	T or F
Lepidoptera (butterflies and moths)	F
Coleoptera (beetles)	I
Trichoptera (caddisflies)	I
Arachnida	
Phalangida (water spiders)	F
Hydrachnellae (water mites)	F
Mollusca	
Gastropoda	
Mespgastropoda	I
Viviparidae	I
Pleuroceridae	F
Bulimidae	I
Physidae	T
Lymnaedae	F
Planorbidae	F
Ancylidae	I
Bivalvia	
Unionidae	T
Heterodonta	F
Dresissenilidae	F

Reference:

EPA, *Biological Field and Laboratory Methods for Measuring the Quality of Surface Water and Effluents;* EPA, Cincinnati, Ohio 1973.

INVESTIGATION #14

Determination of Several Lake and Pond Parameters

Background:

Standing waters are usually named lakes, ponds, swamps, marshes, or bogs. Lakes and ponds are not easily defined because of the diversity of ways in which they originate and the terms used by people of various regions. The latter three are easier to define. Swamps are wet lowlands supporting large trees and shrubs. A marsh is a broad wet area which is abundant in grasses and sedges. A bog is also a broad wet area characterized by acidic water and characteristic flora such as sedges, sphagnum, and cranberries.

As a general definition for lakes and ponds, the following may be used as a rule of thumb: a lake is a large open body of water while a pond is usually small and often thick with rooted plants growing across it.

Lakes are normally defined in terms of origin. There are about thirteen different ways lakes can form. We will deal with the most common to our area in Ohio. Many of our lakes were formed by glacial action. Punderson Lake, Newbury, Ohio, is a good example of a kettle lake. It was formed when a buried chunk of glacial ice melted, leaving a very deep lake. Lake Erie and the other Great Lakes were formed by the scraping and digging action of the glacier. As the glacier receded, it left large valleys which filled with water. This is called a glacial basin. The other type of common lake in Ohio is the man-made lake. These are usually made by damming a river valley. Some of the well known man-made lakes include Findley Lake, Hinkley Lake, Salt Fork Lake, and Charles Mills Lake.

Objectives:

1. Student can give five different types of lakes classified by origin.
2. Student can make a map of a lake or pond showing the bottom topography.
3. Student can measure parameters of a lake including maximum depth, length, breadth, and surface area.

Materials:

rope marked in meters (50m)
anchored bouys
USGA 15' quadrant map
graph paper
weighted depth rope or sounding plug

Procedure:

1. Go to the library to read about lake origin or formation. Write a report on lake origin including at least five different types of lake origins. Try the following references:

   Reid, George, *Ecology of Inland Waters and Estuaries*; Van Nostrand-Reinhold, 1961.

   Coker, Robert E., *Streams, Lakes, Ponds*; Harper Torch books, 1968.

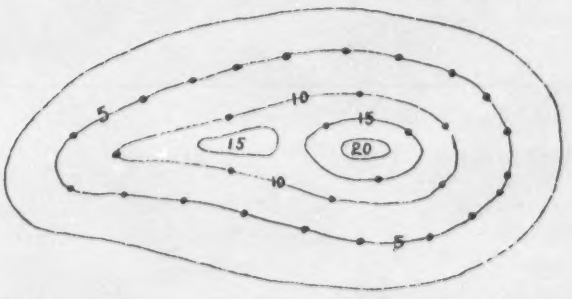
   Use the card catalog to locate other books with good information.
2. To measure the length of a lake, you measure the distance between the farthest points on the shore line. On small lakes or ponds, direct measurements can be made. On larger ones the procedure is more difficult to obtain a direct measurement. In this case a USGA quadrant map may be used to determine the length. How would you determine the length of Lake Erie?
3. Breadth or width measurements of a pond or lake is taken at right angles to the length. The width of different points may vary if the lake is irregular, so an average width is determined by taking various measurements along the length.
4. Surface area of a lake is usually calculated by plotting the lake on graph paper. Calculate the area of one square (depending upon the scale used in plotting) and determine the number of squares within the boundaries of the lake.

Determination of the Area of a Lake Using Graph Paper Estimates

Number of whole squares enclosed X 1	= ____
Number of ¾ squares enclosed X ¾	= ____
Number of ½ squares enclosed X ½	= ____
Number of ¼ squares enclosed X ¼	= ____
Total whole square equivalents enclosed	= ____

*The total number of squares enclosed X the area represented by one square = total area of lake.

5. Topographical map. For this activity you will need a boat, life jacket, map of the lake, and a depth sounder. To make a topographical map you need to measure the depth of the lake many times at different points around and across the lake. The size of the lake and the accuracy of your map determines the number of measurements needed. Your map should look similar to this when completed.



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6. Maximum depth is the deepest location in the lake. This should have been found during the survey in the preceding step.

Evaluation:

1. What factors might affect the size of a lake or pond?
2. Over the years, what are the general changes which occur in a lake or pond?
3. What are the possible errors in the mapping of the lake topography?

For further investigation:

1. Calculate the volume of the lake under study.
2. Determine the extent and development of shoreline.

INVESTIGATION #15

Algae Sampling and Identification

Background:

Algae in general may be defined as small plant-like organisms of relatively simple structure. The size range is extreme, from a few microns to over three hundred feet in length. Algae may be observed commonly as scum on farm ponds, gold-brown slime covering rocks in streams, or large brown kelp of the ocean. Algae is found in almost every body of water.

To go into detail on algae would take a great amount of time and space. It is therefore suggested that you go to outside references to get a good background before starting this investigation. The following are references which you might read:

1. Bold, Harold, *Morphology of Plants*; Harper and Row, New York, 1967. pp. 9–103.
2. Odum, E. P., *Fundamentals of Ecology*; Saunders Company, Philadelphia, 1959. p. 300
3. Otto & Towle, *Modern Biology*; Holt, Rinehart and Winston, Inc., New York, 1969, pp. 310–329.
4. Samllwood & Green, *Biology*, Silver Burdett, Dallas, Texas, p. 261.
5. USHD, APHD, *Standard Methods for the Examination of Water and Waste Water — 13th Ed.*; APHD, Washington, D.C., 1971.

Objectives:

1. Students can correctly describe the basic characteristics of each phylum of algae including: blue-green (Cyanophyta), green (Chlorophyta), brown (Chrysophyta), and pigmented flagellates (Pyrrophyta).
2. Students can identify at least 4 Chlorophyta, 4 Cyanophyta, 3 Chrysophyta, and 2 Pyrrophyta seen in a natural plankton sample.

Materials:

plankton net
Kemmer water bottle
1 liter bottle
bucket
Lugol's preservative
1 liter settling column
microscope
microscope slide

Procedure:

1. Collection: Collection of a plankton sample may be done in several ways:
   a. Use of a plankton net: Plankton nets have a very small mesh. They collect all but the smallest forms of algae. For a *qualitative* sample you can simply tow the net through the water by throwing it out and towing it in. Algae will concentrate in the collecting tube. For a *quantitative* sample, a known quantity of water must be poured through the plankton net. The concentrate can then be counted and enumerated.
   b. Use of the Kemmer water bottle: The Kemmer water bottle gives you the ability to sample a known quantity of water from a certain depth. Water from the sampler must be concentrated before counting or identifying. (See Part #2)
   c. Surface dip method: Using a one liter bottle, fill the container from the water's surface. Concentrate before counting or identifying. (See Part #2)
2. Concentration and preservation: It is often difficult to count or identify algae if the organisms are not abundant. The concentration can be done in the following manner:
   a. Using a specially prepared settling cylinder, add 1 liter of the sample. Add 5 ml of liquid dishwashing detergent and 5 ml of Lugol's preservative. (See Fig. 1).
   b. Invert the mixture several times to mix it thoroughly. Let the sample settle for 24 hours. Draw off the solution to 50 ml and place this remaining 50 ml in a bottle which should be stored in the refrigerator. Keep the sample refrigerated until you have identified the algae through the use of a microscope.

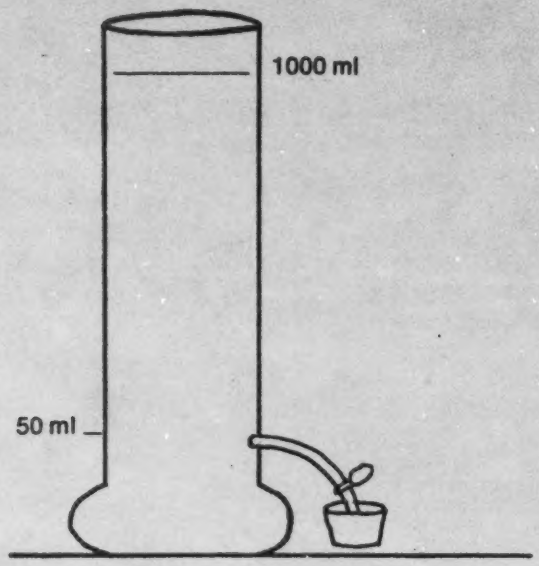


Figure 1 — Settling Cylinder

3. Identification: Identification can be done one of two ways. First by visual comparison. Second by use of an algae key.

a. Using the plates which follow, make a visual comparison to identify the algae. You may also use Table 1 in helping with this identification.
b. To identify the algae use the *Key to Algae* by Prescott. A key may be more difficult to use, but it is usually more accurate.

Evaluation:

1. What is the one most distinguishing characteristic of the Cyanophyta?
2. What is the one most distinguishing characteristic of the diatoms?
3. Why do the algae have such a great diversity of forms?

For further investigation:

Try your hand at counting algae. There are three different methods.

See your instructor for further information.

References:

USHD, APHD, *Standard Methods for the Examination of Water and Water Waste*; Washington, D. C., 1971.

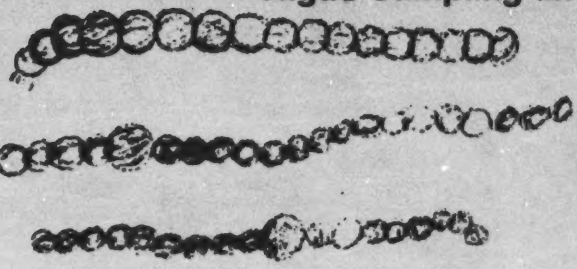
Table 1

Comparison of Four Major Groups of Algae (Modified from Palmer)

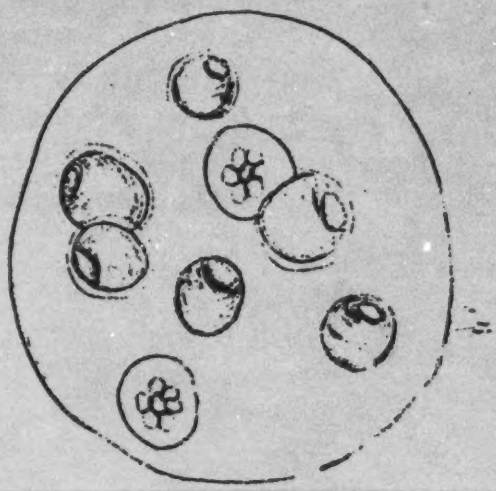
Characteristic	Blue-Green Cyanophyta	Pigmented flagellates Pyrrophyta Euglenophyta	Green Chlorophyta	Diatoms Chrysophyta
Color	Blue-green (brown)	Green	Green	Brown
Locations of pigments	Through out cell	In plastids	In plastids	In plastids
Starch	–	+ or –	+	–
Slimy coat	+	Absent in most	Absent in most	Absent in most
Nucleus	–	+	+	+
Flagellum	–	+	+	+
Cell wall	Inseparable from slimy coat	Thin or absent	Semi-rigid smooth or with spines	Very rigid with regular marks
Eye spot	–	+	–	–

+ present – absent

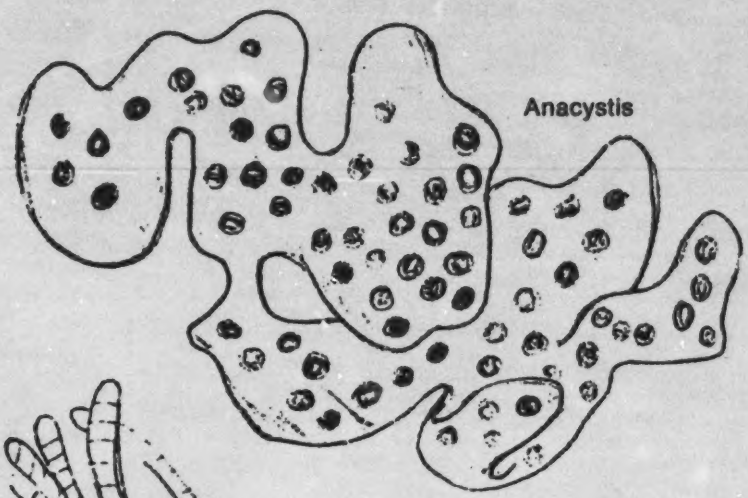
INVESTIGATION #15
Algae Sampling and Identification



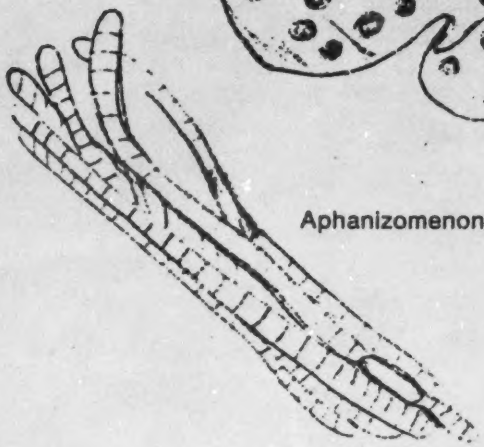
Anabaena



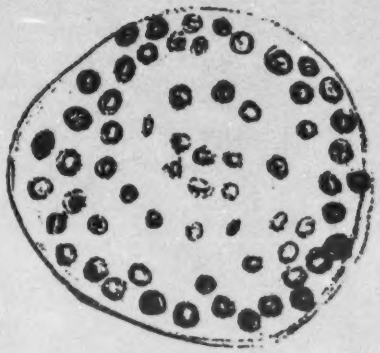
Sphaerocystis



Anacystis

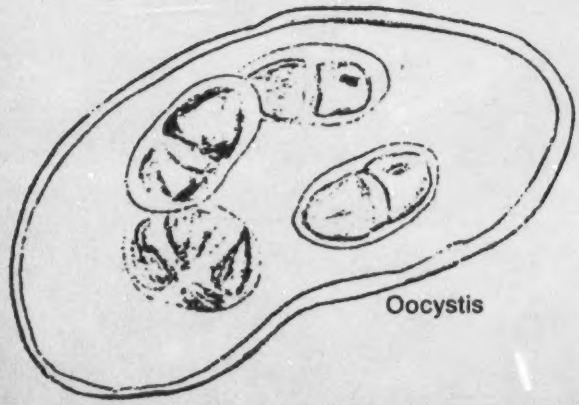


Aphanizomenon



Gonphosphaeria

Gonphosphaeria



Oocystis

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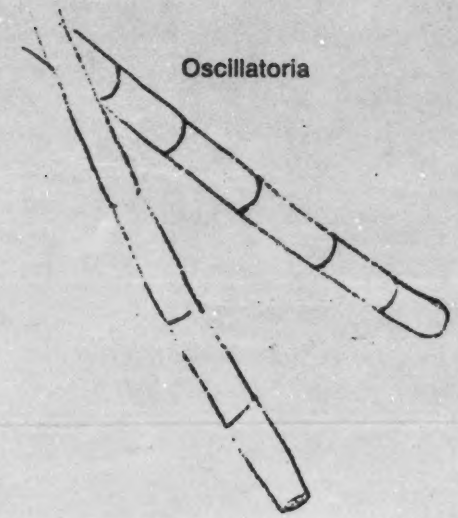
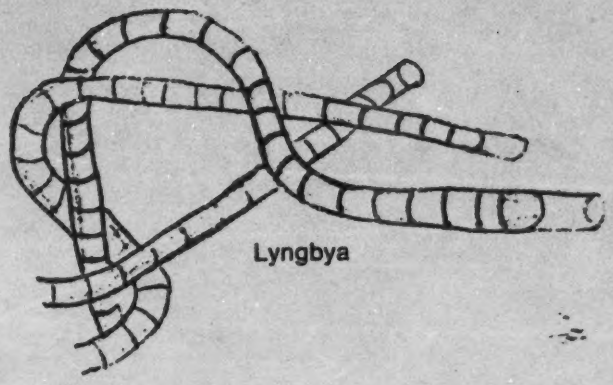
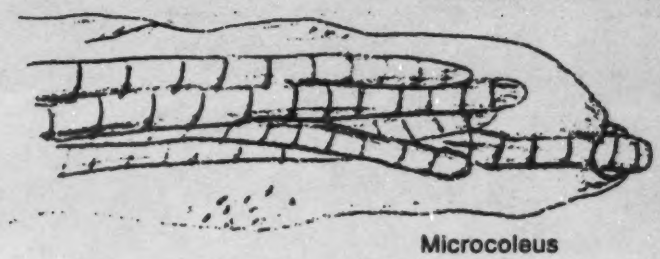
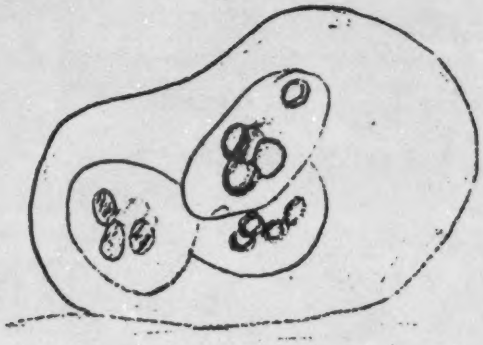
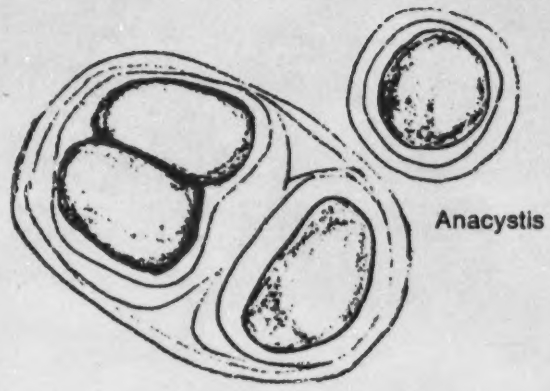
Plate # 1
Blue Green Algae
C. A. Proctor



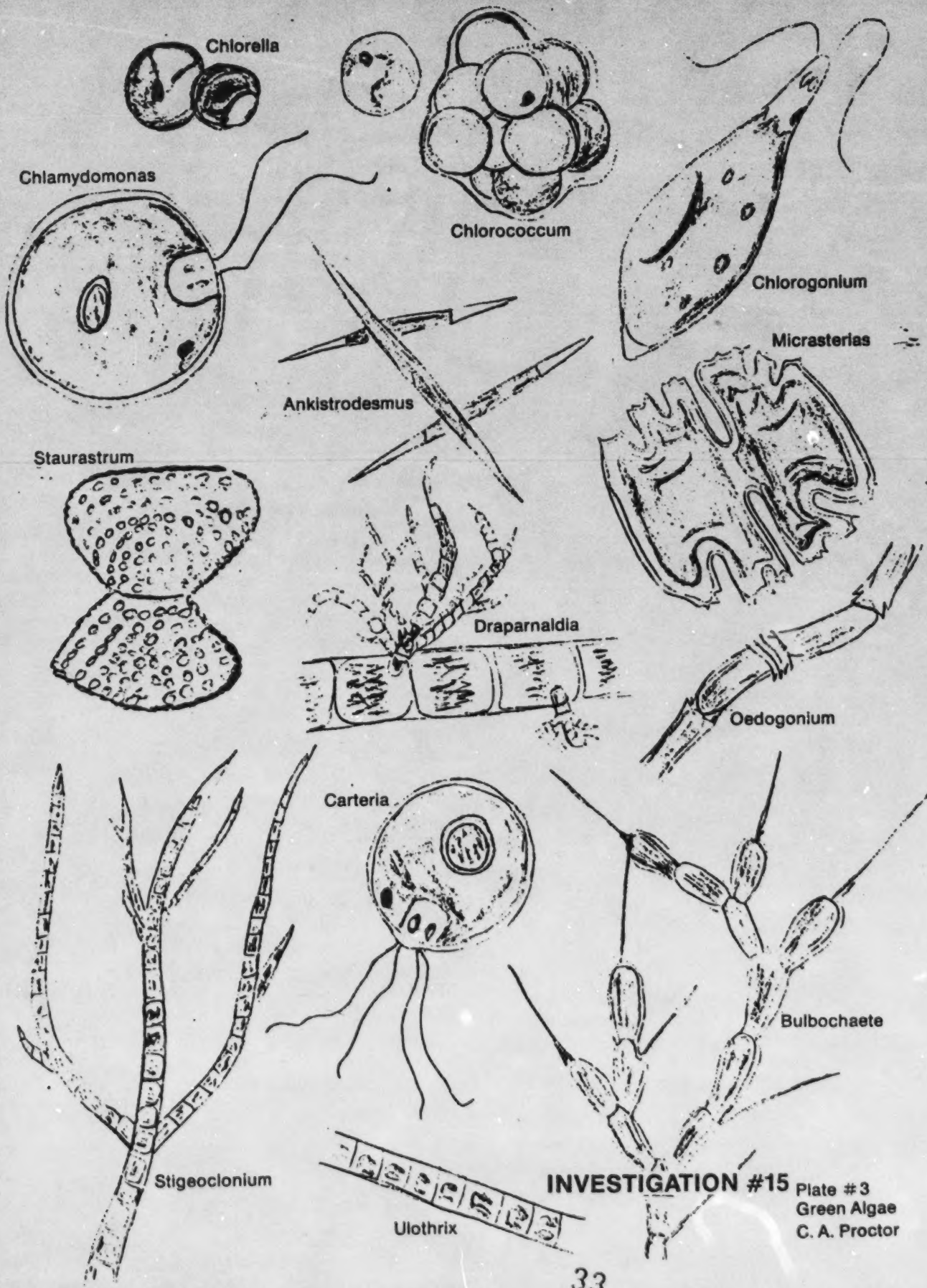








INVESTIGATION #15 Plate # 2
Blue Green Algae
C. A. Proctor



INVESTIGATION #15 Plate #3
Green Algae
C. A. Proctor

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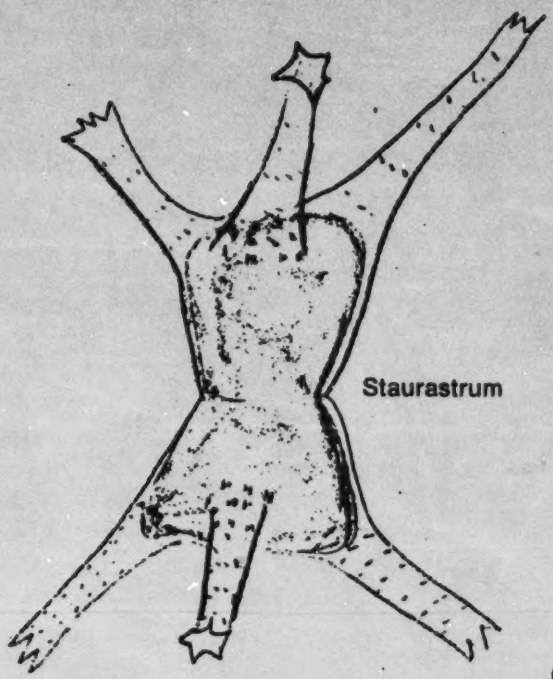

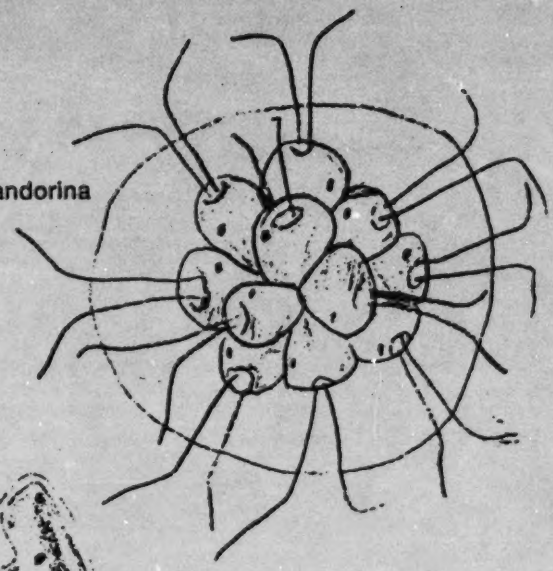

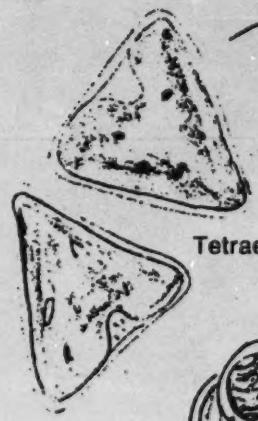

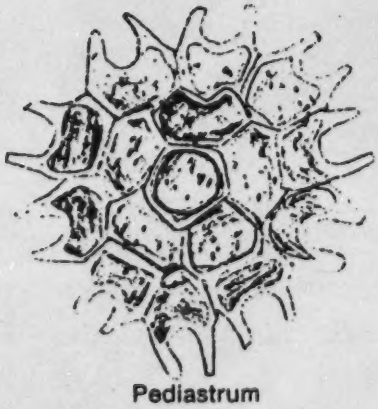

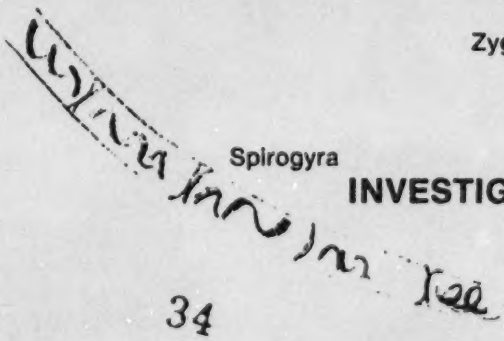

INVESTIGATION #15

Plate #4
Green Algae
C. A. Proctor

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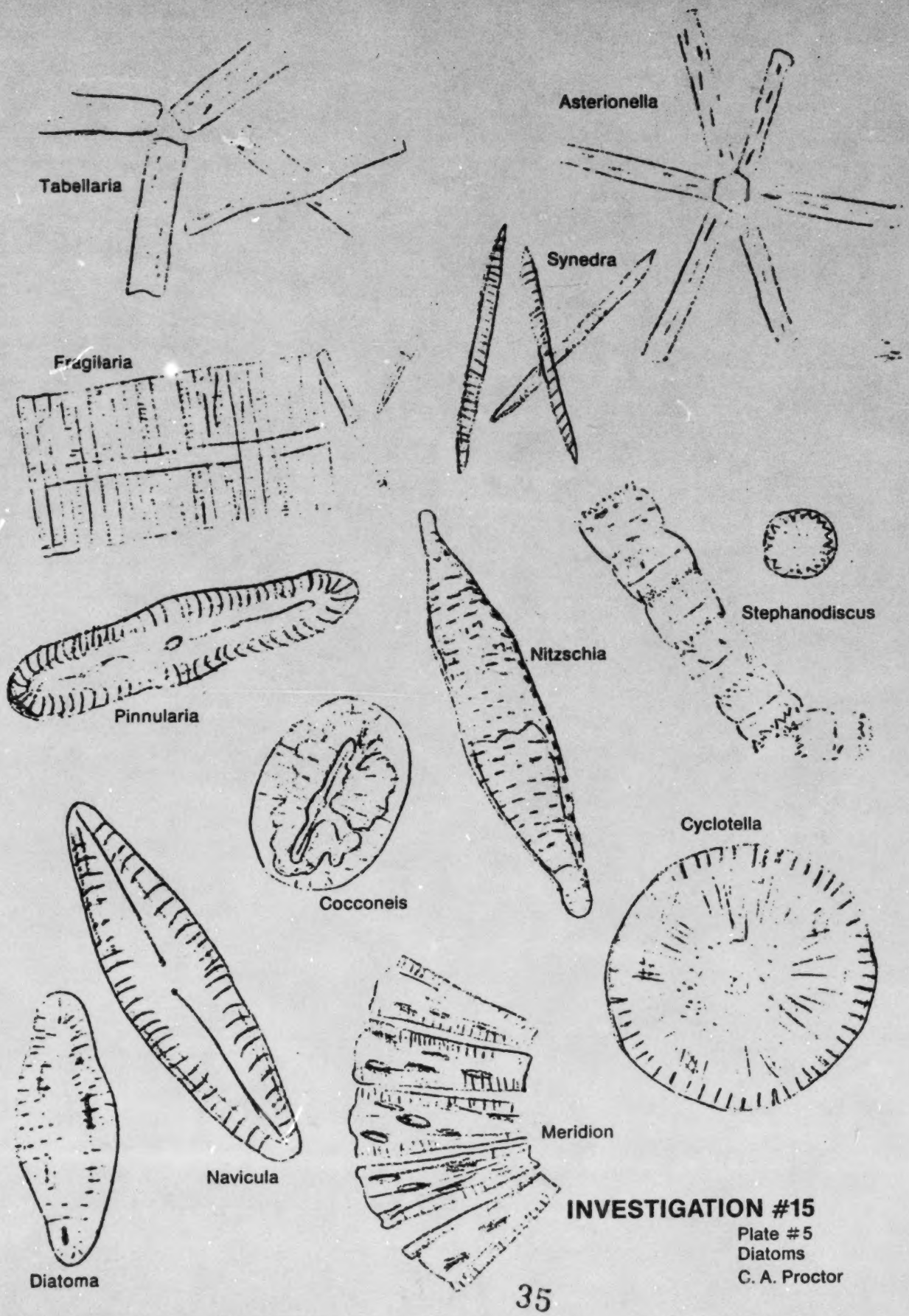

INVESTIGATION #15

Plate #5
Diatoms
C. A. Proctor

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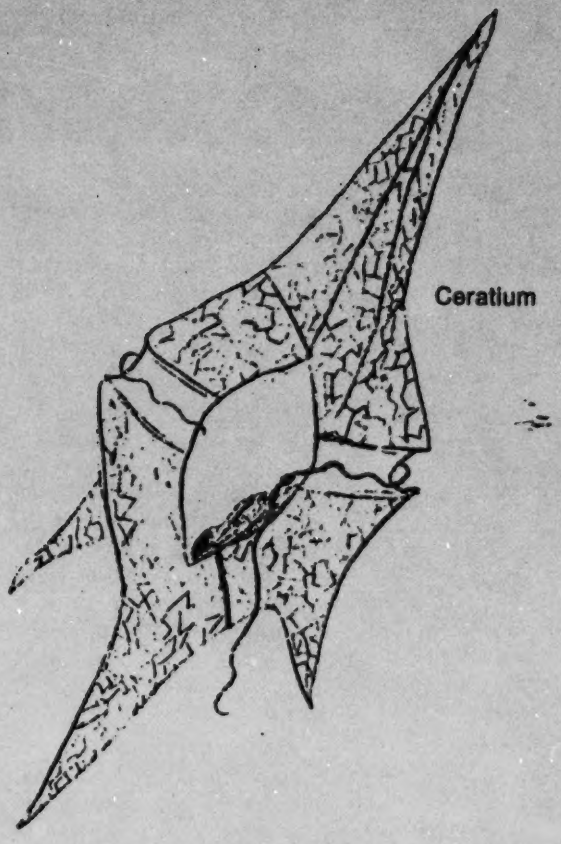

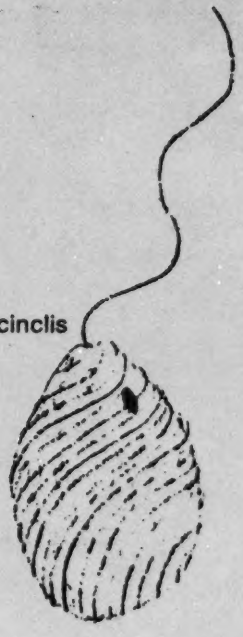

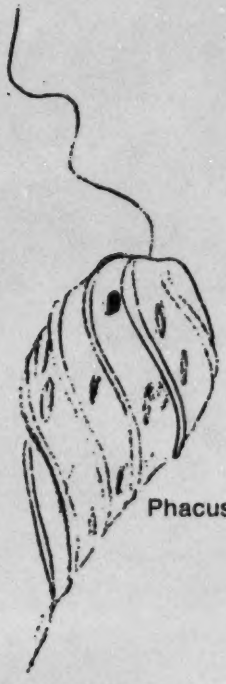

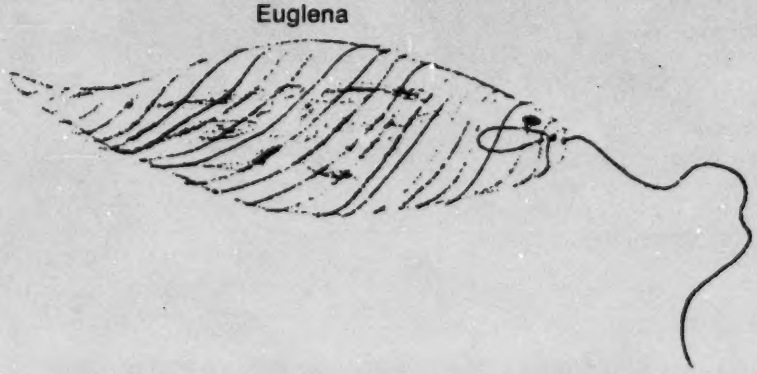

INVESTIGATION #15 Plate #6
Euglenoids and Dinoflagellates
C. A. Proctor

INVESTIGATION #16

Determination of Organic Pollution By Use of Algal Index of Tolerant Genera — Palmer Index

Background:

This lab is based on a paper which appeared in the Journal of Phycology 5: 1969. The article was written by Mervin Palmer who works for the Federal Water Pollution Control Administration, U. S. Dept. of the Interior, Cincinnati, Ohio. He compiled information on pollution — tolerant algae from reports of 165 authors.

Palmer devised an algal pollution index which may be applied to a body of water. The index is based on the genera of algae found in the water as compared to the known genera frequently found in polluted water. Palmer has listed the sixty most pollution-tolerant genera in order of decreasing emphasis. Each genera has been given a value number. The higher the number, the more tolerant the genera is to pollution. From that list a pollution index was made using the 20 most tolerant algal species. In general, the higher the value for the body of water, the higher the organic pollution.

One note on the use of pollution indexes. A pollution index is not always the most accurate method of determining if a body of water is polluted. Other factors must be considered before a definite statement can be made. Many pollution indexes can be misleading since pollution indicator organisms may also be found in clean water. Modifications can be made for individual differences in bodies of water. You might like to read Palmer's article to get a better understanding of the use of an index.

Objectives:

1. Student can accurately determine how many of the 20 most pollution-tolerant genera of algae are in a water sample.
2. Student can determine the pollution index for the lake or pond using the total points as rated by the author.

Materials:

water sample from lake or pond (concentrated quantitatively)
algae counting cell — microscope
microscope slide — dropper

Procedure:

1. Using a Palmer counting cell or a Sedgewick-Rafter counting cell, identify and count the number of each genera identified.
2. From the sample counted, determine the number of each organism per milliliter. (Instructor will review method)
3. Using the chart below, determine the pollution index for the body of water. Total the pollution index points for each algae present. To be counted as present in the body of water there must be a minimum of 50 individuals per milliliter.

Algal Genus Pollution Index

Anacystis	1
Ankistridesmus	2
Chyamydomonas	4
Chlorella	3
Closterium	1
Cyclotella	1
Euglena	5
Gomphonema	1
Lepocinclis	1
Melosira	1
Microastinium	1
Navicula	3
Nitzschia	3
Oscillatoria	5
Pandorina	1
Phacus	2
Phormidium	1
Scenedesmus	4
Stigeoclonium	2
Synedra	2

4. Determine the possible amount of organic pollution. A total score of 20 or greater for a sample is taken as evidence of high organic pollution; while a score of 15–19 is taken as probable evidence of high organic pollution. Lower figures indicate that the organic pollution of the sample is not too high; that the sample is not representative; or that some substance or factor interfering with algal persistance is present or active.

Evaluation:

1. What factors add to organic pollution?
2. Why might some genera survive better in polluted water?

References:

Palmer, M., "Determination of Organic Pollution by the Use of Algal Index of Tolerant Genera"; *Journal of Phycology* 5: 1969.

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INVESTIGATION #17

Rooted Aquatic Plants

Background:

Within the littoral zone plants are divided into two main types: rooted or benthic plants belonging mostly to the phylum Spermatophyta (seed plants) and Phytoplankton or floating green plants which are mostly algae. Duckweed, which is not attached to the bottom is important and in some cases heavy growth can shade out other green plants.

Typically, rotted aquatic plants are concentrated within the littoral zone, one group replacing another as the depth of the water increases. There are three zones within the littoral zone with each zone having its own characteristic plants. Figure I shows the succession of plants within the littoral zone.

Zone of emergent vegetation: This zone contains rooted plants with the principal photosynthic surface projecting above the surface of the water. CO_2 is obtained from the air while the other raw materials and minerals are obtained from beneath the surface. Some common emergent plants include cattails, bulrush, and arrowhead.

Zone of rooted plants with floating leaves: The most common plant in this zone is the water lilly. This zone is similar ecologically to the previous one, but the horizontal photosynthetic surfaces more effectively reduce light penetration, into the water. The upper surface of the leaves are in contact with the air for gas exchange. The undersurface of the leaves are in contact with the water and provide a convenient place for aquatic organisms to deposit eggs.

Zone of submergent vegetation: These are the rooted plants which are completely or largely submerged. The leaves tend to be thin and finely divided, an important adaptation for the exchange of nutrients and gasses. *Potomogeton* or pond weed is one of the most common of submergent plants in our area. Other common submergent plants include *Myriophyllum*, *Elodea*, *Ruppia*, and *Ceratophyllum*.

Objectives:

1. Student can correctly identify three different plants from each of the three zones: emergent, floating and submergent.

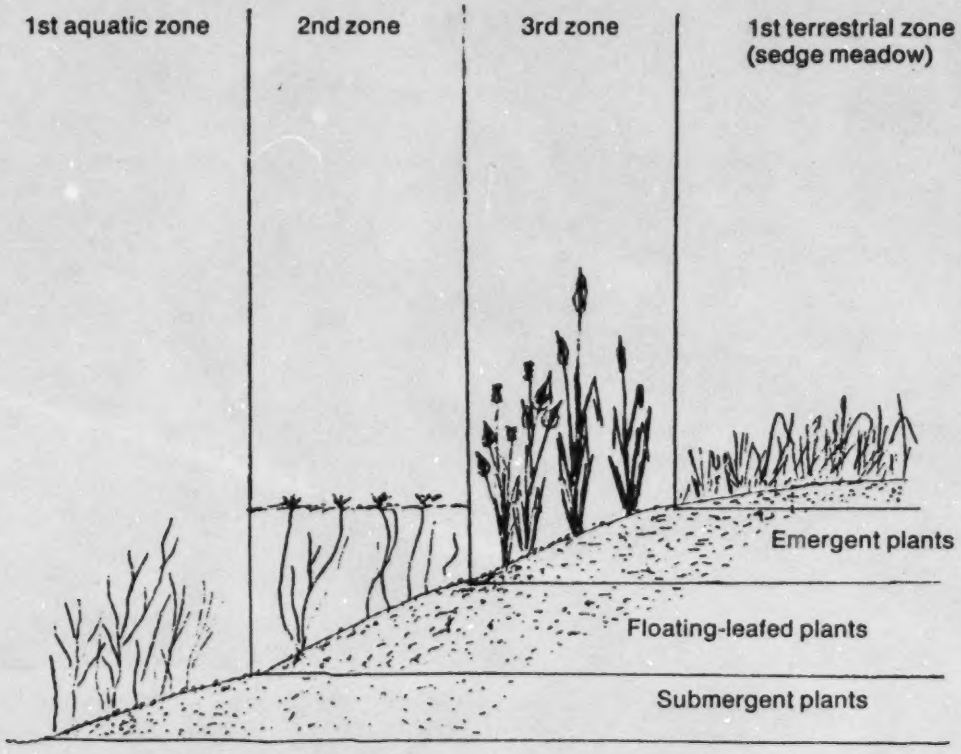

Plate #7 — Succession of Aquatic Plants

D. Fabritius

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Materials:

bucket
plastic bags
labels
keys to the aquatic plants
dip net
boots
grappling hooks

Procedure:

1. Check several references on aquatic plants to become more familiar with the common plants in our area.
2. You will have to go to a stream or pond to collect aquatic plants. Try to obtain several different plants from each of the three zones. (Remember, collect only one of each plant) Place plants in a plastic bag and label the bag for further identification. Include the following information: name, date, location collected, zone collected, bottom characteristic, and speed of water flow.
3. Return to the laboratory to identify the plants collected. Using either a key or the drawings on the next several pages, identify the plants which you collected. If you have problems, ask your teacher for help.

Optional:

Place the plants collected in a plant press. They should dry for about one week and then be mounted on herbarium paper. Fill out an identification card for each specimen and glue this card to the lower right hand corner of the mounting paper. (Please type all the information requested on the I. D. card.)

Evaluation:

1. What are the effects of shading by the floating leaf plants?
2. How does the leaf structure differ in plants found in the different zones? How do the differences benefit the plants?
3. If you compare aquatic plants of a river or stream with those of a lake or pond, how do you think they would differ?

Reference:

American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, *Standard Methods for Examination of Water and Wastewater, 13th Ed.*; American Public Health Association, Washington, D. C., 1970.

INVESTIGATION #18

Transect Study Of A Marsh

Background:

Shallow freshwater marshes tend to be naturally fertile ecosystems. They are characterized by soil waterlogged during the growing season; often covered with 6 or more inches of water.

The general public prejudice against marshes, however, is understandable since they are sometimes the home of mosquitoes and other disease carriers and pests. Before much was known about the life history and ecology of the arthropods and snails as disease carriers, destroying their habitat was about the only solution.

Although grasses are the dominant marsh vegetation, other plants are there. In shallow, open water between the cattails and the reeds, algae is abundant, especially the green, coarse, threadlike Spirogyra and the net-forming Hydrodicton. Floating on the water's surface may be the silt-covered, jellylike alga, Nostoc.

Plant life in the marshes supports a rich and abundant animal life. Snails, one of the most common marsh animals, feed on ooze and dead animal matter and in turn are consumed by birds and fish. Birds, such as ducks, coots, and rails, add the most color to marshlands.

The most typical mammalian member of the marsh community is the muskrat. This rodent uses cattails, sedges, and other plants to build its moundlike lodge, and it subsists on their roots and leaves.

In addition to producing ducks and fur-bearers, marshes are valuable in maintaining water tables in adjacent ecosystems. An example of an interesting stretch of freshwater marsh is the Florida Everglades, which are characterized by fluctuating water levels.

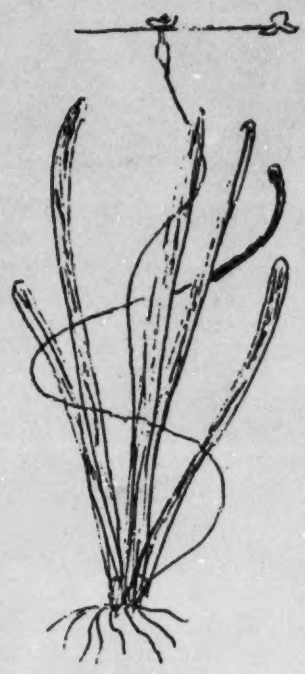
Objectives:

1. To transect study a shallow freshwater marsh.
2. To identify characteristic animal and plant species of a marsh community.
3. To map a shallow freshwater marsh.
4. To study the interrelationship between organisms in a marsh and to report on this ecosystem.
5. To sample the soil from various levels of the marsh.
6. To list reasons for maintaining marshes.

INVESTIGATION #17
Rooted Aquatic Plants

Water Milfoil
Myriophyllum

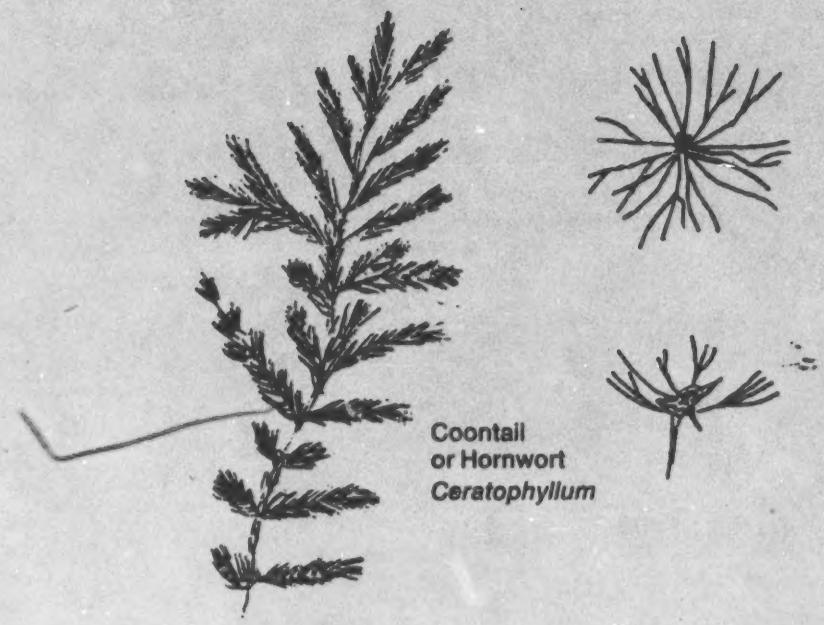
Naiad
Najas



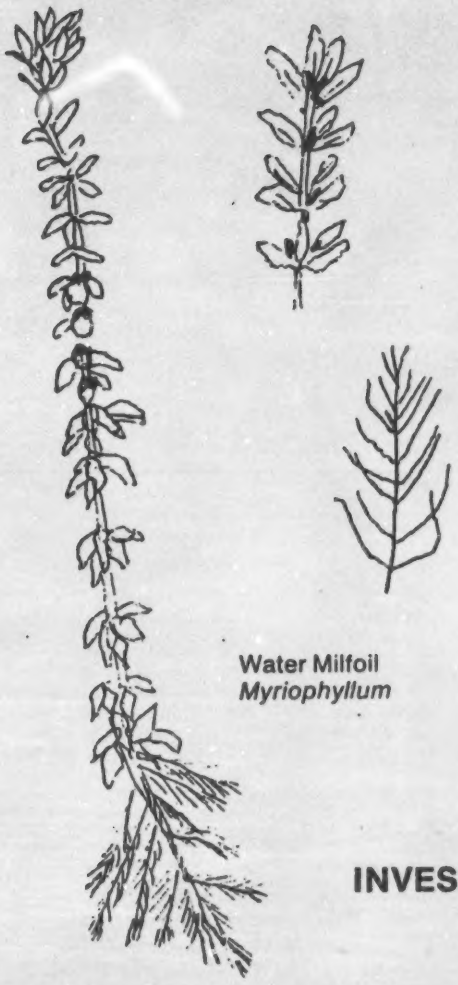
Eelgrass
Vallisneria

40

Plate # 8
Submersed Aquatic Plants
D. Fabritius



Coontail
or Hornwort
Ceratophyllum

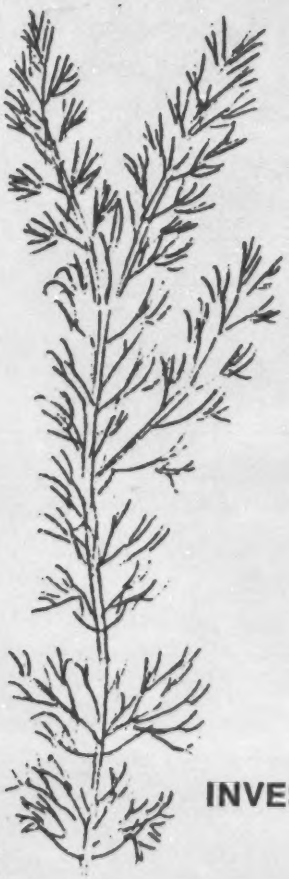


Water Milfoil
Myriophyllum

INVESTIGATION #17 Plate #9
Submersed Aquatic Plants
D. Fabritius

Pondweed
Potamogeton

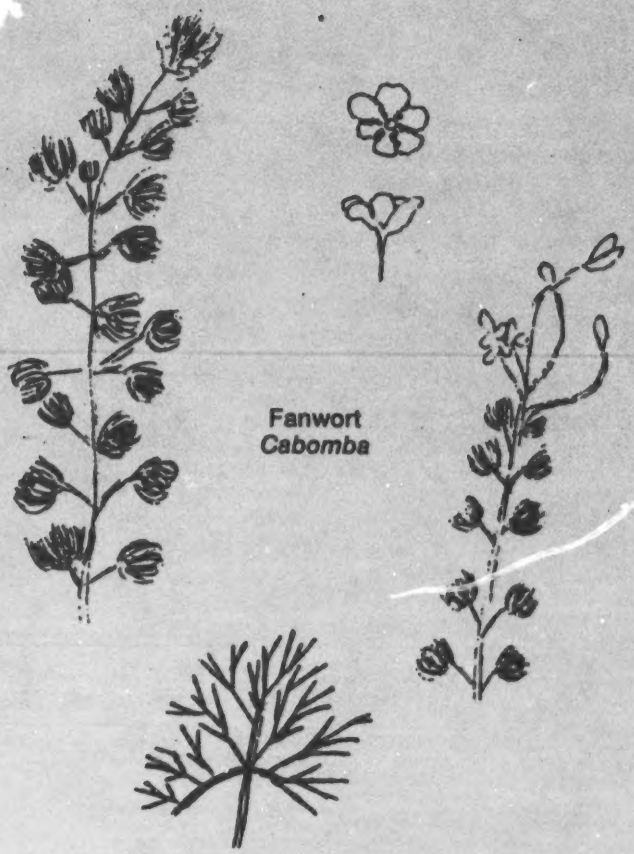
Waterweed
Elodea



Coontail
Ceratophyllum

INVESTIGATION #17

Plate # 10
Submersed Aquatic Plants
D. Fabritius



Fanwort
Cabomba

Stonewart
Nitella

INVESTIGATION #17

Plate # 11
Submersed Aquatic Plants
D. Fabritius

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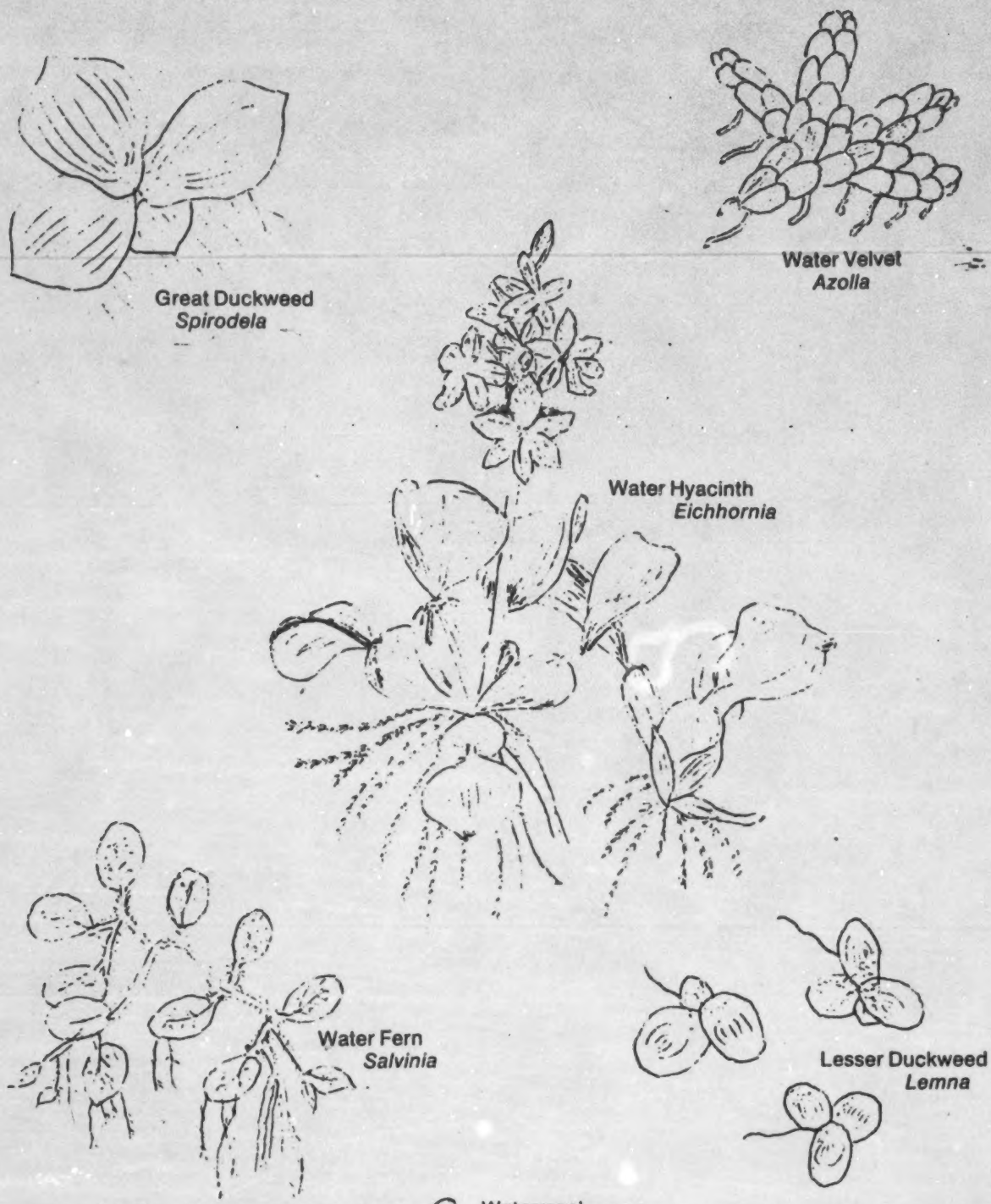
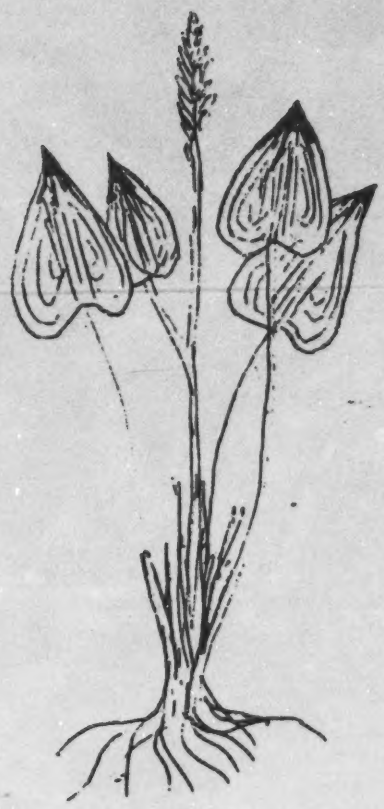


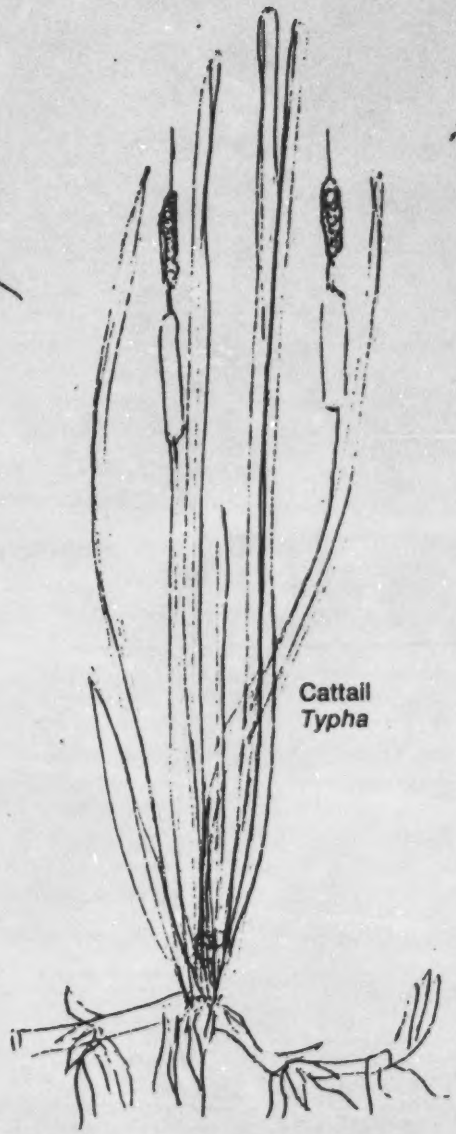
INVESTIGATION #17

Plate # 12
Floating Aquatic Plants
D. Fabritius



Pickerelweed
Pontederia

Sweetflag
Acorus



Cattail
Typha

INVESTIGATION #17

Plate # 13
Emersed Aquatic Plants
D. Fabritius

Calla

Sagittaria

Spike Rush
Eleocharis

INVESTIGATION #17

Plate # 14
Emersed Aquatic Plants
D. Fabritius

Materials:

boots
Ekman dredge
white sorting trays
collecting jars; containers
metric steel tape or chain
soil auger
quadrant frames
hand lens
sieves
microscopes
seines
slides and cover slips
methyl cellulose

Procedure:

Groups of 3 should work together on this activity. Be sure to determine tasks before going to the marsh.

1. Set up a measured transect line from the edge of the marsh to the open water (or as close to it as possible) and along it locate a series of stations. At each station, probe with a soil auger within a quadrant frame. Also check vegetation within the frame. Take water samples. Collect with a sieve, taking a set number of sweeps in each frame along the line. Do the same with a seine. (See Smith, p. 614)
2. Note the changes in the vegetation along the transect. Indicate on a map the location of the shrub zone and measure its distance. Do the same for the sedge mat, and identify and list the species growing there. (For mapping, see Smith, p. 606 and p. 184)
3. Observe the animal life. Determine the characteristic animal species and the zones that they inhabit. (Fig. 4–2, p. 184 in Smith's *Ecology* is very helpful.)
4. After spending some time in the field collecting animal and plant specimens, marsh soil and marsh water, return to the laboratory and carefully examine the materials: Use the reference books for identification. Run chemical and physical tests on the water and soil (temperature, oxygen, pH). Write a descriptive report about the marsh you examined.
5. Research the interrelationship between organisms in a freshwater marsh, and write up a summary report. Include what stage of succession a marsh is in, as well as the value of maintaining marshes. Find out how we can control undesirable species such as mosquitoes and disease carriers in a marsh without eliminating the marsh.

Discussion:

1. Read and talk about the descriptive reports of the marsh.
2. Discuss the interrelationship of organisms within the marsh.

Evaluation:

1. Quiz:
   1) What is a freshwater marsh?
   2) Construct a typical food chain in the marsh you examined.
   3) How can we control undesirable species in marshes without draining or filling in the areas?
   4) List 2 or 3 valuable reasons for maintaining marshes.
   5) Name 3 characteristic animals found in a marsh. Do the same with plants.
2. Collect the maps and reports from each of the student groups and evaluate them for accuracy and understanding.

References:

1. Odum, E. P., *Fundamentals of Ecology*; Holt, Rinehart and Winston, New York, 1963.
2. Smith, R. L., *Ecology and Field Biology*; Harper and Row, New York, 1966.

INVESTIGATION #19

Microorganisms in the Soil

Background:

The number and type of bacteria found in soil depends upon the type of soil and the flora and fauna of the area being examined. Most bacterial life exists near the surface where food and oxygen are available. Many bacteria are considered decomposers and modify the organic matter in the soil into their own nutrients. Only limited numbers and types of bacteria live in the subsoil. Most of the bacteria living more than 18" deep are anaerobic and live without the presence of oxygen.

Objectives:

1. Student can determine the number of microorganisms in various types of soil.
2. Student can determine the different types of microorganisms found in different types of soil.

3. Student can use sterile techniques in bacteria detection.

Materials:

6 sterile vials for soil samples
Millipore filter (sterile)
6 sterile test tubes for dilutions
vacuum pump
sterile water
innoculation loop
H-A type filter — 47 mm
total count media
forceps
(nutrient broth)

Procedure:

1. Using sterile sample tubes with caps, collect the following samples:
   a. surface soil-forest (deciduous)
   b. subsoil-forest (deciduous)
   c. surface soil-meadow
   d. subsoil-meadow
   e. surface soil-marsh
   f. subsoil-marsh
2. Separate the samples into surface soil and subsoil samples.
   surface soil — a, c, e
   subsoil — b, d, f
   Use the dilution method for a, c, and e and do a direct extraction from b, d, and f. (See Step 4)
3. Dilution method: Add 10 ml of sterile water to a 5 g sample of soil. Shake well and let settle.
   Using a 1 ml pipette transfer 1 ml of the settle sample (middle of water) to 99 ml of sterile water (1:100 dilution). Skip to Step 5.
4. Direct method: Add 100 ml of sterile water to a 5 g sample of subsoil. Shake well and let settle. Go to Step 5.
5. Filter 100 ml of sample with sterile H-A filter. Use a pressure of 10 psi. (Do not exceed 15 psi).
6. Transfer H-A filter to plastic petri dish with an absorbent pad. Add 2 ml of nutrient broth.
7. Incubate for 48 hours at 37°C. If too many colonies are present for counting, make an additional 1:100 dilution of the original dilution (Steps 3 and 4).
8. Using the dilution factor to calculate the number of microorganism colonies, determine the number of microorganisms in the original sample.
   Example. 250 colonies x 100 ml water x 10 ml water ÷ 5 g soil = (dilution factor)
   :
   number of bacteria per gram of soil.
9. Observe colonies: Determine how many are bacteria, fungi, or yeasts. (Ask your instructor for help). Use color, colony shapes, and surface to classify different bacteria.

Evaluation:

1. Why did we dilute the soil samples to try to isolate individual colonies?
2. How many different types of bacteria did you find in each area? Yeasts? Molds?
3. Can you give a possible explanation for your results in the different types of soils and subsoils?
4. Did you find all the microorganisms in the subsoil samples that were in the surface soil samples? Why or why not?

Reference:

Millipore Corp., "Techniques for Microbiological Analysis"

INVESTIGATION #20
Properties of Soil

Background:

In this investigation we will study several properties of soil such as texture, color, temperature, pH, and water holding capacity. Below are tables describing these characteristics.

Objectives:

1. Student can recognize the different soil layers (horizons).
2. Student can describe the characteristics of soil including color, texture, temperature, and pH.

Soil Textures

Texture	Water Holding Capacity	Looseness of Soil
sand	poor	good
silt	good to excellent	good
clay	high, but not available to plants	poor

Soil Colors

Color	Aeration	Moisture	Fertility
Dark (dark gray, brown to black)	excellent	high	excellent
moderately dark	good	moderately high	good
light (pale brown, yellow)	low	low	poor
dull gray	poor	water logged	poor
yellow, red-brown	fair	moist, well drained	fair
Mottled gray	fair	wet	poor

Soil Temperatures

Temperature	Characteristic
Below 8°C (40°F)	Little or no growth, some bacerial or fungi Z growth
8°C to 12°C (40°–60°F)	Some plant growth—good bacterial growth
12°C to 15°C (65°F–70°F)	Fast plant growth—fast bacterial growth
15° to 20°C (70°–85°F)	Slow growth for plants—moderate bacterial growth
above 20°C (above 85°F)	No plant growth—thermophylic bacteria

pH

1	4.5	6.5	7	8.5	14
1–4.5 too acid for most plants		most plants		8.5–14 too alkaline for most plants	

Examples of plants found in a given pH range:

pH 4.0–5.0—rhododendron, camellias, azaleas, blueberries, ferns, spruce

pH 5.0–6.0—pines, firs, holly, spruce, oak, birch, willow, tomato

pH 6.0–7.0—maple, ash, pansy, aster, peaches, carrots, lettuce

pH 7.0–8.0—grass, mock orange, asparagus, sagebrush

Materials:

4 stakes
rope
shovel
meter stick
soil thermometer
pH kit

Procedure:

1. Choose two different habitats to compare. Follow the procedure for each. Stake out a 1 square meter plot.
2. Describe the organic matter at the top of the soil. Classify it as litter, duff, or humus.
   Litter — identifiable dead organic matter
   Duff — partially decomposed organic matter compacted
   Humus —almost completely decomposed non-identifiable organic matter.
   Use table #1 for your observations.
3. Using a shovel, dig a shovel full of dirt. Try to keep the dirt from separating or crumbling. Mark where the soil changes color or looks. Measure the thickness of each layer. Record data in Table #2.
4. Describe the color of each layer. Record your observations in Table #2.
5. Determine the texture of each layer of soil as: a. sand — gritty; b. silt — smooth and slick, not sticky; c. clay — smooth, plastic, packs easily, very sticky. Record your observations in Table #2.
6. Measure the temperature of the soil for each layer. Record your data in Table #2.
7. Using a pH kit, determine the acidity or alkalinity of the soil. Record the data in Table #2. Follow the directions on the pH kit.
8. Make an estimate as to the capacity of the soil to hold moisture. This can be done by comparing the color and texture. Check the table in the background. Record your conclusions in Table #2.
9. Try to predict what type of plant life can grow in the area. In the next lab you will check your prediction. List your idea of the types of plants that can grow in this soil in the space provided below or record this information in your notebook.

Table #1—ORGANIC Matter

Area	Soil Surface Type	Soil Description	Identifiable Organic Matter
Area 1			
Area 2			

Table #2—Soil Layers

Characteristic	Layer 1	Layer 2	Layer 3	Layer 4
Number of layers				
Depth				
Texture				
Temperature				
Soil pH				
Water holding capacity (good, fair, poor)				

Reference:

U. S. Forest Service, *Investigating Your Environment Series*: Portland, Oregon, 1972.

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INVESTIGATION #21

Comparison of Animal Life in Grazed and Ungrazed Grassland (A contract assignment — students undertaking this investigation should do so after doing a transect study of a grassland community.)

Background:

Only in the prairies and the plains do the distinctive grassland animals, such as buffalo, prairie chickens, and prairie dogs, live. Within the several strata of vegetation, the roots, ground layer, and herb cover, much of the animal life exists. Invertebrates, particularly insects, which occur in an incredible number and variety of species, occupy all strata at some time during the year. Homoptera, Coleoptera, Lepidoptera, Orthoptera, Diptera, Hymenoptera, Hemiptera, all are represented.

In the grasslands, mowing results in the destruction of habitat, particularly at the height of the nesting season. Using grass for ensilage also eliminates nesting cover and forces most of the population elsewhere. This is one of the causes for the decline of bobwhite quail and cottontail rabbits as farm game species.

The two most common inhabitants of pasturelands are the killdeer and horned lark, even then the land has been overgrazed.

Grazing too early in the spring to allow the plants to grow sufficient food reserves for winter soon upsets the natural balance of the range. The grasslands degenerate, and this affects the animal population.

Objectives:

1. To compare animal life in a mowed area and an unmowed area at the Outdoor Education Center.
2. To study the effects of grazing on the grassland, and to report the results of overgrazing where such practices are evident.
3. To draw a typical food web for a grazed grassland and an ungrazed grassland.

Materials:

In the Field

measurement and fencing materials; pliers, wire
spade
collecting jars, boxes, bags
notebook, marking pen
Peterson, *A Field Guide to the Birds*
trowel
insect nets
quadrants
dyed bait

In the Laboratory

microscopes
triple beam balances
drying oven
Berlese funnel
potassium permanganate
soil test kit
reference materials

Procedure:

Select a suitable grassy area at the Outdoor Education Center that can be fenced in. Observe this plot carefully; photographs will be useful. This sample plot will be used for analyzing ungrazed grassland. Next to, or near this area, the grassland will be studied for the effects of grazing. (You will probably have to find a pasture where cows, horses or sheep graze for this comparison to be meaningful.)

Use the same procedure suggested in a Transect Study of a Grassland Community for sampling each of these areas.

Another technique for sampling might be followed is that of removal sampling. (See Odum, *Ecology*, pp. 18–20) Odum describes the removal of invertebrates and vertebrates. Larger consumers can be directly counted, as with birds. The decomposer groups cannot be studied by removal. The best method for studying them is by the metabolism of intact populations.

Direct measurements of metabolic rate of the producers can be made in litter and soil. (Odum, *Ecology*, pp. 20–21)

Evaluation:

— Quiz

1. What plants increase in population under grazing?
2. What would happen if a certain animal population became overcrowded in the ungrazed area?
3. Are there any dominant animals living in either area? Describe them and their habits.
4. What is the long range value of doing such a study?

Evaluation:

— Other

1. Food web drawing
2. Quiz score
3. Written report on the results of overgrazing

References:

1. Buchsbaum, Mildred & Buchsbaum, Ralph, *Basic Ecology*; The Boxwood Press, Pittsburgh, 1957. (Chapter #4)

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2. Odum, E. P., *Ecology*; Holt, Rinehart and Winston, New York, 1963.
3. Smith, R. L., *Ecology and Field Biology*; Harper and Row, New York, 1966.

Note: This investigation will have to be contracted for at least a month in order for the students to sample and analyze the areas several times a week.

INVESTIGATION #22

Transect Study of a Grassland Community

Background:

Grassland occurs on all continents; at one time grasses covered 42 per cent of the earth. The grasses which characterize this biome are perennials which continue to grow even after their tips have been eaten. This growth supports grazing mammals, and these have reached their greatest numbers in grassland habitats.

In every grassland — whether the North American plains and prairies, the South American pampas, Asian t'sao-yuan, African veld or Australian savanna — locomotion is one of the most important adaptations for survival because grazers are ideal prey for carnivores. Leaping over the tops of the grass enables such creatures as rabbits, and deer to scan the horizon for danger. Burrowing makes use of another level — it offers concealment and reduces competition.

In North America, the jack rabbit is a leaping herbivorous mammal. The prairie dog and ground squirrel are burrowing mammals that feed above ground. The pocket gopher is a burrowing mammal which feeds underground. Pronghorn antelopes and bison are running herbivorous mammals, while coyotes are running carnivorous mammals.

All the organisms in a complex food chain are vulnerable to any physical change that strikes at the base of the pyramid, the primary producer — the grasses.

Natural grasslands occur where rainfall is intermediate between that of desert lands and forest lands. Grasslands are one of the most important of terrestrial ecosystem types. About one third of the United States is grassland, the rest being mostly forest land and a relatively small total area of true desert, marsh, estuaries, and alpine tundras. Dominant plant-life forms are the grasses, which range from tall species (5 to 8 feet) to short ones (6 inches or less) that may be bunch grass types (growing in clumps) or sod formers (with underground rhizomes).

The grassland community builds an entirely different type of soil as compared to a forest, even when both start with the same parent mineral material. Since grass plants are short lived as compared to trees, a large amount of organic matter is added to the soil.

Grasslands possess essentially three strata, the roots, the ground layer, and the herbaceous layer. Within the several strata of vegetation, much of the animal life exists. Invertebrates, particularly insects, which occur in an incredible number and variety of species, occupy all strata at some time during the year. Earthworms, ants, carabid beetles and spiders are some of the other organisms.

Temperature, rainfall, wind direction and velocity are the major physical factors which affect the occurrence of grasslands.

Objectives:

1. To sample an area of grassy field at the Outdoor Education Center using transect methods.
2. To examine the essential strata of the grassland — the roots, the ground layer, the herbaceous layer.
3. To identify some of the autotrophic organisms collected.
4. To identify some of the heterotrophic organisms collected.
5. To dig a soil trench to observe the soil profile, the distribution of organic matter and the distribution of plant roots.
6. To construct a pyramid of biomass for this area.
7. To compare a grassland community with a forest community.

Materials:

In the Field
metric tape or steel chain (33.5 meters)
spade
collecting jars, boxes, bags
notebook, marking pen
Peterson, *A Field Guide to Birds*
trowel
insect nets
quadrants
dyed bait (Smith, p. 648)

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In the Laboratory
microscopes
triple beam balances
drying oven
Berlese funnel
potassium permanganate
soil test kit
reference materials

Procedure:

The grassland (an old field) ecosystem is well adapted for the study of community structure and function. The plant material can be sampled, as well as the animal populations.

As a class, decide which transect method you are going to use for this activity. (See Smith, pp. 613–618). Then, divide into small groups. *Group A* should set up the transect a day before the class goes into the field. These students are to collect data from the other groups as the investigation progresses. *Group A* is also responsible for sampling the earthworm population by the potassium permanganate method.

Group B sample the plant material by harvesting. (Smith, pp. 630–631).

Group C sample the insects. (Smith, p. 637)

Group D sample the soil arthropods. (Smith, p. 637)

Group E set out dyed bait and sample the small mammals. (Smith, p. 648) (If possible)

Group F determine the density and composition of the breeding bird population. (Smith, p. 649)

Group G study the soil by analyzing and testing, then constructing a profile. (Smith, pp. 245–246)

Time spent in the field, in the laboratory, and in reference work will vary for each group, so a time limit should be placed for the completion of this investigation.

The collected data (by Group A) should be given to the entire class so that each student can construct a pyramid of biomass (Smith, p. 40), interpreting the information. This will be handed in to the teacher for evaluation. A comparison with a forest community should be made next so that this accumulated data can have some meaning.

Discussion:

1. Some time should be allowed for the examination and discussion of a few of the pyramids.
2. What are the advantages and disadvantages of using a transect method of sampling the grassland?
3. Relate the autotrophic strata with the heterotrophic strata in the grassland sample.
4. What plants dominate the upper strata? The lower?
5. After having studied an old field, discuss why grasslands are one of the most important of terrestrial ecosystem types.

Evaluation:

1. The field and lab work
2. The pyramid of biomass and interpretation
3. The discussion

References:

1. Buchsbaum, Mildred & Buchsbaum, Ralph, *Basic Ecology*; The Boxwood Press, Pittsburgh, 1957.
2. Odum, E. P., *Ecology*; Holt, Rinehart and Winston, New York, 1963.
3. Oosting, H. J., *The Study of Plant Communities*; W. H. Freeman Co., San Francisco, 1956.
4. Sears, Paul B., *Lands Beyond the Forest*; Prentice Hall, Inc., Englewood Cliffs, N. J., 1968.

INVESTIGATION #23

Identification of Trees Using a Dichotomous Key

Background:

What is a "key" to trees? A key puts the characteristics of a tree into a series of choices which lead to the name of the tree. It is like the "true and false" quiz and an excellent way to identify trees.

There are several points of identification to consider; leaf, bud, bark, relative thickness of trunk and twigs, color of twigs, taste of twigs, color of under bark, pith color and whether the pith is divided with cross partitions, flowers, fruit, seeds, style of branching — whether trunk separates into limbs or whether it goes from ground to top with branches coming off at wide angles. Hairiness, smoothness, roughness, and luster of parts are also considerations. As you approach a tree, its general outline is often specific. For example, the fountain of the American elm, the long oval of sugar maple, the broken, wide-reaching outline of the black willow are evident. Other identification factors might be accessory growth, such as thorns, and corky ridges of bark. The breathing pores of barks are prominent in birches and cherry trees.

Objectives:

1. To identify fifteen of the numbered trees along the trails of the Outdoor Education Center.
2. To classify the trees by using a dichotomous key describing the leaves.
3. To solve the tree identifications by using additional clues such as sap, bark, taste of twig, etc.
4. To learn external leaf structures and be able to identify 13 of the 15 collected leaves on a quiz.
5. To find an adequate method to preserve and mount leaves.

Materials:

In the Field
8½" X 11" notebook
small pocket knife
list of the 15 numbered trees to be identified (2, 3, 5, 30, 42, 43, 48, 53, 55, 60, 62, 63, 80, 85, 86)

In the Laboratory
some good keys to trees
microscopes (dissecting)

Procedure:

1. Before you go on the trail to collect leaves, do some reading about keying and classifying trees. Look for information about preserving leaves for a short time, or indefinitely. Note some reasons for tree identification.
2. Collect representative leaves from each numbered tree (you should find fifteen). Place the leaves in your notebook until you can preserve them properly. When possible, collect several leaves attached to the same twig so that you can tell if the leaves are arranged alternately, oppositely or if they are whorled. Note descriptions of each tree from which leaves are collected.

Note characteristics of leaves in this order:

   a. Arrangement: whorled, opposite, or alternate
   b. Simple or compound
   c. Edges: entire or toothed
   d. Texture: leathery or soft
   e. Luster: shiny or dull
   f. Average size if fully grown
   g. Proportions

For additional clues, you may have to note thorns, sap, bark, taste of twig and nature of pith. To observe the pith, split the twig lengthwise using a sharp knife.

3. Classify each of the fifteen leaves using dichotomous keys available in the lab.
4. After you have identified your leaves, check their identity with your teacher. Once you have studied the basic structure and types of leaves, inform your teacher that you are ready for a quiz.
5. Hand in your best preserved leaf mount along with a separate sheet indicating the steps in the key you used in your identification. You should also indicate the method of preservation and mounting you used for your specimen.

Evaluation:

1. Score on the leaf quiz
2. Method and execution of leaf preservation and mounting

Further Inquiry:

1. Key ten other trees along the trails at the Outdoor Education Center.
2. Use methods of tree identification other than the leaf. Shape of tree, height, bark texture and color and leaf scars are some significant clues.
3. Make your own dichotomous key for trees numbered one through ten along the Hiker's Trail. Check the accuracy of your key by having a friend try to use it successfully.

References:

1. Collingwood, G. H., *Knowing Your Trees*; American Forestry Association, Washington, D. C.
2. Graves, A. H., *Illustrated Guide to Trees and Shrubs*; Harper and Brothers, New York, 1956.
3. Jaques, H. E., *How to Know the Trees*; William C. Brown Company, Dubuque, Iowa, 1946.
4. Petrides, George A., *A Field Guide to Trees and Shrubs Sec. Ed.*; Houghton Mifflin Company, Boston, 1958.
5. Platt, Rutherford, *1001 Questions Answered About Trees*; Dodd, Mead and Company, New York, 1958.
6. Sargent, Charles S., *Trees of North America*; Houghton Mifflin Company, Boston, 1922.

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INVESTIGATION #24

Weeds — Collecting and Keying a Few Common Weeds of the Outdoor Education Center

Background:

"A weed is a plant out of place. Thus, human desire is the determinative factor." Plants may be classed as weeds because they are unsightly, poisonous, mechanically injurious, competitive to the growth of a crop, or detrimental to the harvesting of a crop. Many highly useful species may become weeds when growing in the wrong place. Thus, volunteer wheat in a soybean field may be just as much a weed as poison hemlock in a pasture, hardwood trees in a pine forest, or mesquite on the range. Some weeds waster water through transpiration, clog irrigation systems, drainage canals, and sewer lines, compete for nutrients, change the taste of food, or make water unpalatable. Other weeds provide benefit to the soil by soil building. In addition to soil building, weeds were the mother of medicine. It is surprising how many weeds are still found listed in the pharmacopoeias of the world. Even the dandelion is among the medicinal plants which include catnip, burdock, mustard, Jimson weed, and a great many more that are not so well known.

Objectives:

1. To identify and classify 5 common weeds of the Outdoor Education Center
2. To identify what makes a weed a weed
3. To list weed contributions to nature's cycle and man's benefit
4. To identify weeds in the yard or area near my home
5. To list some of the best known methods of eradicating pestiferous weeds

Materials:

In the Field.
8½" X 11" notebook
small trowel
dittoed pictures of 5 specific weeds found in the O. E.C.

In the Laboratory
hand lens
dissecting microscope
pictured key to common weeds
reference books on weeds

Procedure:

Almost all of our common weeds belong to the flowering or seed-bearing group of plants which numbers about a quarter million species. Weeds are never lacking in abundance and rarely does anyone object to their collection. However, make certain that you are collecting the properly specified weeds by comparing the drawing of each with the actural specimen in the field. Then carefully dig around the weed loosening the soil. Shake the excess soil from the one specimen you select. Place the plant in your notebook, being careful that the leaves, flowers and roots are not folded unnecessarily. Continue until you have collected the five specimens indicated in this activity.

After returning to the laboratory, observe the weed samples, comparing the root systems, leaves and flowers. Use the dissecting microscope or hand lens when necessary. Identify each weed according to the key to common weeds. Indicate the scientific names as well as common names (often called English names).

Find some information about each of the weeds in the reference books and then write a paragraph about their usefulness or pestiferous nature.

Attach each weed to your notebook paper with small strips of tape. Paper clip your five sheets together before handing in your completed weed study. Include the identity of each classified weed and the requested information about each.

Further Investigation:

1. Research some of the methods known to eradicate pesty weeds.
2. Collect and properly identify weeds from your lawn, garden or recreation area.
3. Experiment with the limits of tolerance of weeds. You can use dandelions, chickweed, etc.
4. Compare loss of water from purslane and a tomato plant.

Discussion:

Take some time to share ideas gained from the reference reading about weeds. Ask about the beneficial aspects of weeds, particularly their medicinal value. Consider some of the modern methods used to eradicate pesty weeds. What has been the overall effect on the ecology due to indiscriminate spraying?

Evaluation:

Evaluate the weed study each student submits as well as their contributions to the discussion on weeds.

Additional Information:

1. Jewel Weed (Wild Touch-Me-Not) — (*Impatience biflora* Walt) The "touch-me-not" is very plentiful at the Outdoor Education Center. It is sometimes called quick silver because

the leaves appear to be silvery when placed underwater. The plant contains a sap that counteracts the oils of poison ivy. For this reason it is sometimes used to prevent poison ivy by rubbing the weed on the contacted area. The "touch-me-not" refers to the way the seed pod behaves; impatiently flying to pieces and curling up when touched.

2. *Hairy Vetch (vicia villosa)* The species is grown as a forage crop and often persists in fallow fields and dry open ground. Its stems are covered with spreading hairs and its violet and white flowers are large and attractive.
3. *Yarrow (Achillea millefolium)* Lacy-leafed, rather fragrant smelling plant that bears a corymb of small white, somethimes pink, flowers at the top of a lacy-leafed stem. Yarrow is medicinal in nature. Its tea is used as a tonic, and it is said to be a good remedy for severe colds, since it acts as a stimulant and produces perspiration.
4. *Devil's Paintbrush (Hieracium aurantiacum)* Flowers are orange-red. If it were not such an agressive weed, it might gain popular favor as an ornamental.

References:

1. Coon, Nelson, *Using Plants for Healing*; Hearthside Press, Inc., New York, 1963.
2. Coon, Nelson, *Using Wayside Plants*; Hearthside Press, Inc., New York, 1969.
3. Fogg, John M., *Weeds of Lawn and Garden; A Handbook of Eastern Temperate North America*; University of Pennsylvania Press, Philadelphia, 1945
4. Spencer, Edwin W., *Just Weeds*; Charles Scribner's Sons, New York, 1957.
5. Wilkinson, R. E., Jaques, W. C., *How to Know the Weeds*; Brown Company Publishers, Dubuque, 1972.

INVESTIGATION #25

Study of the Subdivisions of a Forest Community

Background:

The deciduous forests are richly developed in North America wherever there is moderate precipitation and mild temperatures during the growing season. A well developed deciduous forest usually consists of four strata:

1. The upper canopy consisting of dominant and co-dominant trees
2. The lower tree canopy
3. The shrub layer
4. The ground or field layer which contains the herbs, mosses and ferns.

Because of the strata of the forest composition, there is also a stratification of light, temperature and moisture. The forest canopy, or lack of canopy, affects the amount of light and rainfall that falls to the forest floor in every season of the year.

Not only do the above factors influence life over a forest region, they also influence the distribution of life between ground level and the upper strata. Temperature, wind, light, moisture, etc., differ from level to level and this in turn affects the animal and plant life.

Objectives:

1. To examine the subdivisions of the forest community
2. To identify the various environmental factors which affect forest stratification
3. To sample the arthropod population and classify a few of the specimens.
4. To determine what producers and consumers inhabit the community and to compare their numbers

Materials:

hammer
carpenter's square
trowels
stakes (100 cm in length)
plastic clothesline, 12 m length marked at 0.5 m intervals
60 m of twine
beating net
collecting bottles
large plastic bags
chloroform
meter sticks
three bottles with 30 to 50 ml of distilled H_2O
sling psychrometer
table of relative humidities
wristwatch

Procedure:

1. Stake out the forest area chosen by your group for study. Using the marked clothesline, measure off 10 m in any direction from a stake driven into the ground. Drive a second stake at this point and connect the two stakes by twine that is drawn taut. Place a carpenter's square at the second stake with the short leg along the twine.

INVESTIGATION #24
Weeds—Collection and Keying a Few Common Weeds of the Outdoor Education Center

PLATE #15
Daisy Fleabane, White Top
Erigeron annuus L.

A. McCluer

INVESTIGATION #24
PLATE #16
Orange Hawkweed, Devil's Paint Brush
Hieracium aurantiacum L.

A. McCluer

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INVESTIGATION #24

PLATE #17
Hairy Vetch, Winter Vetch
Vicia villosa Roth

A. McCluer

INVESTIGATION #24

PLATE #18
Yarrow, Milfoil
Achillea millefolium L.

A. McCluer

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INVESTIGATION #24

PLATE #19

Touch-Me-Not, Jewel Weed, Quick Silver

Impatience biflora Walt

A. McCluer

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At 10 m from the second stake and in line with the long leg of the carpenter's square, drive a third stake and connect the twine. Continue around the square. Use twine to mark off two smaller quadrants inside the large one.

2. Write a general description of the staked out area. Divide the plants into three groups: trees, shrubs, and herbs. Use the data sheet to record your information. (Table # II)
   a. Trees over five cm in diameter should be studied in the main quadrat. Note trees that form the canopy separately from those that do not reach the canopy. Make a count of the trees, either by kinds or just as trees.
   b. Count both shrubs and saplings in an area smaller than that used for the trees.
   c. Count both herbs and seedlings on small quadrats. In each small quadrat, estimate the proportion that is covered by moss or other very small plants.
3. After the plant information is gathered, students should work in pairs — one searching while the other records. This activity should be done in the large quadrat. Turn over stones, dead logs and other cover to find animals. Look in and on plants for animal specimens and make notes of the kinds, numbers, and the activities of the animals you find.
4. Using a beating net for collecting, beat the shrubs and saplings, holding the net under the plant during the beating process. After beating, place the contents of the net in a large plastic bag containing several drops of chloroform. Wait a few minutes, then pick out the organisms and place them in jars of alcohol or formalin. Label each jar indicating the collecting date and location.
5. Factors of special importance to land organisms are temperature and relative humidity. A team of six students, working in three pairs, are to measure the relative humidity at ground level, 30 cm elevation, 90 cm elevation and 150 cm elevation. Use a sling psychrometer for all readings and record your data on Table = 1 of your data page.

Discussion:

When the work is completed, the data should be considered carefully in order to answer the following questions:

1. The greatest concentration and diversity of life lies on and just below the ground layer. Explain why and describe some of the organisms.
2. Name various environmental factors which affect forest stratification. How does each factor influence the forest community?
3. What was the dominant species found in each forest stratum?
4. What producers are in the area? What consumers? What relations can you find between the numbers of a particular organism and the numbers or another organism that eats it?

Evaluation:

Choose one of the animals in a particular stratum you observed and do some library research on its niche, food, habits, etc., and submit a written report on your research.

References:

Smith, Robert L. *Ecology and Field Biology*; Harper and Row, New York, 1957.

DATA PAGE

Location **Table #1**

	HEIGHT			
	0 cm	30 cm	90 cm	150 cm
Time				
Dry-Blub Temperature				
Wet-Bulb Temperature				
Relative Humidity				

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DATA SHEET FOR FOREST COMMUNITY **Table II**

General description of staked out area:

_____

_____

Data Collected:

Trees: _____

_____

Shrubs & saplings: _____

_____

Herbs & seedlings: _____

_____

Organisms from searching:

_____

_____

_____

Organisms netted: _____

_____

INVESTIGATION #26:

Study of a Rotting Log Community

Background:

In a rotting log, the microorganisms, beetles, worms, ants, termites, cockroaches, centipedes, and other animals within the log are an integrated and interdependent group of organism living within a restricted habitat that for a time at least, has relatively little to do with the other animals of the forest. But it is not really self-contained; the energy stored in the wood, which supports the community, was originally stored by the living tree. And in the end the log again becomes a part of the forest floor; it is not a lasting community.

A rotting log may go through all its successive stages in a few years, and we can follow the whole process in a single log. A newly fallen beech log is attacked by the pioneering boring beetles which make tunnels in the solid wood. Through such openings, enter other small animals, fungus spores, and water. The tunneling and feeding of the beetles, the growth of the fungi, and the freezing of the water in the winter all help to loosen the bark and to soften the wood. Under the loose bark we can then find many small snails, a slug or two, the larvae of fungus-gnats, and especially the flattened types of beetle larvae. As the wood is softened by the pioneering animals, it no longer supports boring beetles. These boring beetles leave and are replaced by fungus-eating beetles and by the larvae of click-beetles that can burrow only into softened wood. Finally, the bark is completely gone, and the animals that it sheltered no longer remain. Molds and bacteria reduce the pulpy wood to a mound of soft humus in which we can find ants, earthworms, ground-beetles, millipedes, and other animals that also live in the forest floor.

Objectives:

1. To identify the organisms living in a rotting log community
2. To follow the process of succession in a rotting log
3. To trace the original source of energy supporting the community
4. To categorize the symbionts in the rotting log
5. To study one of the rotting log organisms in detail

Materials:

In the Field
magnifying glass
collecting jars
camera

tape measure
spatula
In the Laboratory
sterile innoculating needles
berlese funnel
agar plates
material for terminate box construction
slides and cover slips
methylene blue, safranin, crystal
microscopes
violet and basic fuchsin

Procedure:

1. Walk the trails at the Outdoor Education Center looking for fallen logs. Photograph the log at the beginning of this activity. Return to the log once a month for other photographs. Compare the photographs, noting stages of succession during the time lapse.
2. Observe all the macroorganisms; collect specimens for examination and identification in the laboratory. After returning to the laboratory, set up a Berlese funnel for collecting smaller organisms from the humus-like material of the log.

(See Morholt and Brandwein, Sourcebook for Biological Sciences, P. 521)

3. Sterilize agar plates. Using a Bunsen burner, flame innoculating loops or needles and then innoculate the plates with some of the material from the log. (Use bacteriological techniques.) Observe the growth on the agar plates for several days, and then make wet mounts. Try to identify the bacteria, fungi and other microscopic organisms. Experiment with various stains.
4. Try to determine the cause of the tree falling, the age of the tree, and when it fell.
5. Measure the diameter, and when possible, estimate the height of the tree. Can you determine the biomass? What would you have to do? (See Smith, *Ecology and Field Biology*, pp. 40–46)
6. Collect all stages of termites from the rotting log. Set up a termite community in the laboratory for further study. (See Morholt and Brandwein, *Biological Sourcebook*, p. 605)
   a. Study the social life of a termite community.
   b. Observe symbiotic flagellates taken from the termites.

(See Morholt and Brandwein, *Biological Sourcebook*, p. 537)

7. Make a wet mound of a bit of lichen from the log. Distinguish the green algal cells enmeshed in filaments of fungi. What kind of partnership is here?
8. Select one of the organisms mentioned in the background information and research it. Write a report on what you find.

Discussion:

1. What causes wood to decay?
2. Describe a typical example of mutualism in a rotting log.
3. Why can a rotting log be considered a microcommunity?
4. Trace the stages of succession in a newly fallen beech log.
5. Define: Symbionts; commensalism; mutualism; parasitism; hyperparasite.

Evaluation:

1. Discussion
2. Quiz on discussion material
3. Written report on one of the organisms from the rotting log

References:

1. Morholt, Evelyn and Brandwein, Alexander, *A Sourcebook for the Biological Sciences;* Harcourt, Brace and World, Inc., 1966.
2. Odum, Eugene P., *Ecology;* Holt, Rinehart and Winston, New York, 1963.
3. Smith, Robert L., *Ecology and Field Biology;* Harper and Row, New York, 1966.

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DATA SHEET

Macroscopic Organisms Found in a Rotting Log (Include name of phylum)	Number

Microscopic Organisms Found in a Rotting Log (Include name of phylum)	Number

INVESTIGATION #27:

Collecting and Interpreting Data About Tree Growth Rate and Composition

"The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity; it provides protection to all beings, offering shade even to the axeman who destroys it."

— Gautama Buddha
Founder of the Buddhist religion
circa 525 B. C.

Background:

Why do trees grow quickly in one region, slowly in another, hardly at all in a third? The answer depends on many factors: temperature, rainfall, wind, soil, elevation above sea level and the kinds of plants and animals present, to name only a few.

One conspicuous feature on any freshly cut tree-stump surface is a series of concentric circles of dark and light wood. By learning to interpret clues recorded in these rings, you can uncover many details of the tree's history and of the forest in which it grew.

Annual rings, as these circles are called, result from the fact that trees grow in girth as well as in height. Every year, a new layer of wood forms just beneath a tree's bark. Like a sheath extending up the trunk and around every branch, the layer of new wood envelops the layer of wood formed the preceding year. The lighter portion of each ring represents rapid growth early in the season; the narrower, darker portion indicates the end of the growing season. A few kinds of trees may form more than one distinct layer of wood during a single year, and in an extremely unfavorable growing season, no wood at all, but these are exceptions. As a general rule, each annual ring equals one year of a tree's life.

A microscopically thin layer of cells called the cambium layer is responsible for increasing the diameter of tree trunks, branches and twigs. Each year the cambium layer adds thickness to the sapwood and to the bark which is continually peeling off. The result is a series of annual rings which if counted from the center to the outside of the trunk near its base gives an accurate record of the tree's age. The width of each ring depends upon such factors as rainfall, the amount of sunlight the tree receives, competition with other trees, and so on. The rings sometimes enclose traces of insect and fire damage, and thus the rings not only indicate the tree's age, but also much of its history.

Objectives:

1. To determine the age of a tree by counting the annual rings
2. To assign specific dates to events recorded in the tree's annual rings, i. e. insect epidemic, little rainfall.
3. To make a permanent record of a stump's tree-ring history
4. To identify the anatomy of a tree and the function of each structure
5. To list raw materials available from a mature tree after cutting

Materials:

notebook and soft lead pencil
hand lens
sandpaper
onionskin paper (cut in 2-in. wide strips with one end pointed like an arrow)
2 thumbtacks

Procedure:

1. Look for a freshly cut tree-stump which has been cut at or near ground level. (If the tree was cut well above the ground, the record of its earliest years will not be visible.) Recently cut stumps are easiest to read. When a stump has been exposed to the weather for several seasons, the tree-ring record becomes blurred. In such a case, smoothing the surface with sandpaper will usually make the rings show up more distinctly.

   To make a permanent record of a stump's tree-ring history, place and tack a strip of thin white paper from the center of the stump to the bark at the edge. Rub lightly on the paper surface with the broad edge of the point of a soft-lead pencil.

   The annual rings will show up on the paper as dark lines alternating with lighter areas. After returning to the laboratory, mark the dark lines with ink. This will provide a convenient, durable record of the tree's growth history.
2. Count the annual rings to determine the age of the tree.
3. If you know the year that the tree was cut, you can assign a specific date to events recorded in any annual ring. Example: Cut in 1974. The third ring and successive 3 or 4 rings are narrow. Explanation — Slow growth because of little rainfall. So you can figure out the year or years that there was little rainfall. Check with the yearbook of weather statistics to verify the year or years of little rainfall registered on the tree stump.
4. Record the tree's age and as much of its history as you can determine. Attach your stump's record of annual rings to another sheet, adding its history, and hand in to your teacher for evaluation.
5. Using reference books, study the anatomy of a tree so you can identify structure as well as function: roots; trunk (outer bark, inner bark, cambium layer, sapwood, heartwood), leaves.
6. Using reference books, list the tree products available from a mature tree after cutting.

Discussion:

1. How old was the tree that you examined? How do you know? Discuss some of the tree's history, explaining how you have arrived at this information.
2. Describe the structure and function of the roots; stem (trunk), leaves of trees.
3. Name some of the many tree products and their uses.
4. Why is it necessary to preserve our forests? What are some practical steps each of us can take to preserve and maintain our forests?

Evaluation:

Each student can be evaluated from the recorded strip of paper, showing the tree stump's annual rings, and his/her explanation of the tree's age and history, in addition to his/her participation in the class discussion.

References:

1. McCormick, Jack, *The Life of the Forest;* McGraw-Hill Book Company, New York, 1966.
2. Ohio Forestry Association Inc., "Woodlands Conservation in Action", Vol. XII, No. 3, The Neil House, Columbus, May — July, 1974.
3. Platt, Rutherford, *1001 Questions Answered About Trees;* Dodd, Mead and Company, New York, 1958.

INVESTIGATION #28:

The Effect of Smoke and Exhaust on Plant Growth

Background:

In addition to carbon monoxide, nitrogen oxides, lead oxides, and ozone, automobile exhaust puts large quantities of ethylene into the air. An idling car produces enough ethylene in one minute to defoliate a full grown tree if the exhaust could be contained. Burning plant material also produces ethylene. For example, cigarette smoke contains 500 to 1,00 ppm ethylene.

Ethylene is a gas with a chemical formula $CH_2 = CH_2$. It is a plant hormone and, therefore, ethylene air pollution has many effects on plant growth and development. Concentrations as low as 0.07 to 0.20 ppm can affect plant growth.

Objectives:

1. To research the importance of ethylene air pollution in cities.
2. To compare the effects of ethylene from an apple, from auto exhaust, and from cigarette smoke on bean plants.

Materials:

36 to 40 beans (string, lima and pinto beans are good)
8 to 10 pots, about 4-inch diameter
enough sterile soil to fill the pots, or use vermiculite or perlite and fertilizer
8 large clear plastic bags, 25 to 26 inches tall by 16 to 18 inches wide
24 sticks, 12 to 15 inches tall
8 wire ties
2 ripe eating apples
2 cigarettes
200 ml of a 5 percent solution of potassium permanganate
1 glass container which will hold at least 300 ml and has a cover
1 graduated cylinder, 100 ml
4 plastic dishes (12 oz. size)
4 circles of filter paper (at least 15 cm in diameter)
1 balance
1 rubber aspirator bulb
1 or 2 short pieces of tubing which will fit the bulb and cigarettes

Procedure:

1. About two weeks before you plan to do the experiment, plant the beans as follows:
   a. Fill the pots about three-fourths full of soil or vermiculite. Water thoroughly with room temperature water. Evenly space four beans on top of the soil and cover lightly with about ½ inch of dry soil.
   b. Place the pots in good light and keep moist with room temperature water but do not overwater.
   c. Keep the plants above 65°F.
2. When the plants are about two weeks old, water thoroughly. Thin the plants so that there is one plant to a pot. Thin by cutting off the extra plants near the soil.
3. Weigh 10 g of the potassium permanganate and dissolve it in 200 ml distilled water in a covered glass container. Do not spill the permanganate solution as it will stain.
4. Make a smoking machine by hooking the cigarette to the tubing and to the aspirator bulb.
5. Number the pots 1 through 8. Try to pair the plants so that 1 and 2 are similar to each other in height and leaf size, plants 3 and 4 are similar, etc.
6. Put each plant into one of the plastic bags, and arrange three sticks in the pots to support the bags so they do not crush the plants. All the bags should close at the top except those around plants 7 and 8, which should close at the bottom.
7. Fold the filter paper in half and plant them like fans. Open each into a loose cone and place tip down in the plastic dishes.
8. Put the following items in the bags with the plants:
   Plant 1 — nothing
   Plant 2 — plastic dish with paper cone
   Plant 3 — one apple
   Plant 4 — one apple and a plastic dish with the paper cone
   Plant 5 — nothing
   Plant 6 — plastic dish with paper cone
   Plant 7 — nothing
   Plant 8 — plastic dish with paper cone
9. Pour about 50 ml of the potassium permanganate solution into each of the cones in the plastic dishes. The solution should creep up the sides of the paper to give a large surface area to absorb and oxidize the ethylene.
10. Close the bags with plants 1 through 4 and tie tightly with the wire ties.
11. In order to collect automobile exhaust you will need at least two people. (This step must be done under the teacher's supervision.) Do not work in an enclosed area. One person should support the plant and the dish of permanganate solution in the bag. These should be held about two feet away from the end of the tail pipe. While the car is idling, he should hold open the bag so that the exhaust blows into it for about five seconds. The opening of the bag should be at least a foot away from the end of the tail pipe so as to avoid burning the student or the plant.

12. After collecting the exhaust in bags 5 and 6, close the bags and tie with the wires.
13. Mark off 3 cm on each cigarette. Attach the tubing and the rubber bulb to the end of the cigarette, 4 ot 5 cm away from your mark.
14. Hold the cigarette below the opening of bag =7 so that the smoke will rise into the bag. Light the cigarette and slowly squeeze and release the bulb in order to "smoke" the cigarette. Allow only 3 cm of the cigarette to burn, then close and tie the bag.
15. Repeat step 14 with plant 8, being careful not to spill the potassium permanganate.
16. Place all the plants in indirect light, at room temperature, for two to three days.
17. Each day examine the plants and record any changes in a notebook. Look for dropping leaves, and yellow or lost leaves.
18. After three days remove the plants from the bags and carefully describe the condition of each plant.
19. Go to the library and research the effects ethylene has on plant growth and development. Assess the importance of ethylene air pollution in cities. After you have carried out the experiments planned in the laboratory, write a report using the information gained from your library work and that you learned from the experiments.

Discussion:

1. What effects did the apple, exhaust, and smoke have on the plants?
2. Did the presence of the potassium permanganate solution affect the plants?
3. Does it appear that ethylene is an important component of exhaust or smoke?
4. What was the appearance of the plants treated with ethylene from the apple as compared with those treated with smoke and exhaust?
5. Are some of these same effects lessened or missing in the plants exposed to the potassium permanganate solution? If so, why?

Further Inquiry:

1. Try other kinds of smoke, or vary the lengths of time for collecting the smoke.
2. Try other kinds of plants, especially flowers such as carnations or snapdragons.
3. Determine the ethylene level in the air at the Outdoor Education Center. What effect does the ethylene in the air have on the flora there?

Evaluation:

Evaluate the written reports of each student.

References:

1. Abeles, Ann L., Assistant Professor, Science Department; Frederick Community College, Frederick, Maryland (Source of this activity).
2. Barth, D. S., *Air Quality Criteria for Hydrocarbons;* National Air Pollution Control Administration Publications, No. AP-64. U. S. department of Health, Education and Welfare, Washington, D. C., 1970.
3. Clayton, G. D., and Platt, T. S., "Evaluation of Ethylene as an Air Pollutant Affecting Plant Life"; *American Industrial Hygiene Association Journal* 28:151–160, March — April, 1967.
4. Hindawi, I. J., "Air Pollution Injury to Vegetation"; National Air Pollution Control Administration Publication, No. AP-71. U. S. department of Health, Education and Welfare, Washington, D. C., 1970.
5. Hunter, D. C., and Wohlers, H. C., "Air Pollution Control Association," Pittsburgh, Pennsylvania, 1970.

INVESTIGATION #29

Composting . . . A Responsibility!

(A Contracting Responsibility)

Background:

"We must feel our way from a proper care of the land to higher things. The land must be the starting point, so perhaps those who are in a position to influence the treatment of even a small bit of it have the greatest responsibility. Out of their efforts must come that new thing which will not be like anything known before; a new wholeness or harmony in the world of life."

Compost is the core, the essential foundation of natural gardening and farming. It is the heart of the organic concept. The benefits of compost are many, encompassing wide ranging effects on the soil, the growth of plants, and the health and well-being of animals and people who consume plants.

According to Webster's New International Dictionary, compost is a mixture for fertilizing or renovating land in which plants are grown. A fertilizing mixture composed of such substances as peat, leaf mold, manure, lime, etc., thoroughly mingled and decomposed and usually in a heap is called a compost heap.

Microbes play an important part in the composting process. However, if they are to survive and multiply, they must be fed properly on food furnished by the manure and green matter in the heap. Manure supplies nitrogen for the bacteria

to feed on while breaking down the cellulose. The microbes also need phosphorus and potash, but in much smaller quantities. These substances are supplied by both manure and green matter such as lawn clippings, weeds, dry leaves, cured hay and sawdust.

If a compost heap is made correctly, it should begin to heat up in a few days. You can stick a metal rod into the heap and then check to see if it is warm when you pull it out. Another sign that the heap is warming is vapor which can be observed coming out of the aeration holes on cold days. You can mount a thermometer at the end of a stick and by gently forcing the instrument into the composting heap, take daily readings of the internal temperature.

Because fermentation brings about an acid condition under which the microorganisms cannot do their work effectively, it is necessary to provide a neutralizing base which will counteract acidity. Earth mixed with lime or wood ashes is ideal for such purposes. Where lime and wood ashes are not available, earth alone may be used. It requires a mere sprinkling, not over ⅛ inch thick, of topsoil that is rich in bacteria, fungi and humus to do the job.

Objectives:

1. To make an active compost heap maintaining favorable conditions
2. To identify the materials needed to make an effective compost
3. To choose between several compost-making methods, finding one suitable for materials available at the Outdoor Education Center
4. To utilize compost materials at the Outdoor Education Center
5. To identify organisms, both macroscopic and microscopic, that are common to a compost heap
6. To determine the effect of composting on earthworm population

Materials:

The materials to be used in making an active compost heap are to be determined by the student contracting to do this activity.

Procedure:

1. The student and teacher must decide how much time will be devoted to this activity and which of the objectives are to be met. Students are to be encouraged to add additional objectives as work with composting progresses.
2. The first few days should be spent in the library doing research on composting techniques.
3. Materials should be gathered and the compost constructed as soon as a technique is finalized.
4. Keep records of temperature, and pH and make sure that the pile is moistened and aerated regularly.
5. Drawings or photographs of the various stages of the maturing compost heap would be helpful for documentation.
6. When the compost heap is mature, utilize the compost on evergreens or other plants that are being propagated on the site.
7. Take a sample count of the earthworms found in the compost.
8. Bring a small amount of the compost into the laboratory and examine the contents microscopically.
9. When you are prepared, ask the teacher for a quiz on composting.
10. Optional research:
    a. Weigh out pieces of filter paper then place the paper and a known amount of soil into a petri dish. How long does it take the filter paper to lose ½ of its weight?
    b. Add a nitrate fertilizer to mini-compost piles set up in aluminum bread pans. Experiment with various materials and factors such as air, water, etc., to establish optimum conditions.
    c. Run a comparative study of the best kind of water for composting: rain water, pond water, or tap water.

Further Inquiry:

1. Explore the Bio-dynamic system of composting based on the ideas of Dr. Rudolf Steiner.
2. Explore the Indore method of composting by Sir Albert Howard of Indore, India.
3. Explore the Quick-Return system of composting proposed by Mary E. Bruce.

Quiz questions:

1. What values is there in preparing a compost heap?
2. What are some of the materials that can be used to make a compost heap?
3. What do we mean when we say that a substance is biodegradable?
4. List the conditions which are necessary to develop a good compost.
5. Name some of the essential organisms at work in reducing compost to humus.
6. Define: green matter, humus, and pH.

Evaluation:

In addition to the quiz, the student may choose to give an oral report of his/her findings to the class.

References:

1. Billington, F. H., *Compost for Garden or Thousand Acre Farm; A Practical Guide to Modern Methods;* Charles T. Branford Co., Boston, Mass., 1956.

2. Rodale, J. I., *The Complete Book of Composting, Organic Gardening and Farming;* Rodale Books, Inc., Emmans, Penn., 1960.
3. Smith, Robert L., *Ecology and Field Biology;* Harper and Row, New York, 1966.

INVESTIGATION #30

Natural Selection Model

Background:

Charles Darwin accumulated a tremendous collection of facts to support the theory of evolution by natural selection. These facts primarily related to his observations on variation in a number of species. It became obvious to him that the many variations he observed were very often of such a nature to "suit" the organism to a particular environment or niche. Charles Darwin sought to explain how these variations became established within populations. He explained this with the theory indicated in the first sentence. Although his theory has been modified with time and new information, the basic idea he presented is still with us and forms part of the foundation for the study of biology today.

One thing Darwin did not have, was an example of evolution which could be observed as it was taking place in nature. Time and an environment for such observations are not usually available in the course of one's lifetime.

A way to study the theory of evolution by natural selections is to construct a "model" of the living situation. In the construction of a model, assumptions are made which come as close as possible to the "real" situation, however, you should recognize that, at best, the model is a simplification of the real situation. The measure of the quality of a model is the "test" you present to the model. Any theory worth its salt should enable us to make predictions which later can be substantiated. The model will be constructed in the procedure. If our model has value, we should observe the evolution of a color distribution change in the "population" studied (a prediction based on natural selection).

Objectives:

The student can construct a model to study the process of selection in a population.

Materials:

red and green colored toothpicks (200 each)
a grass covered area (approximately 50' X 75')

Procedure:

1. Our model assumes that the grass covered area represents the environment for a population of insects (represented by the colored toothpicks). We will further assume that this environment will support a population of 400 "insects" and that these insects are normally preyed upon by birds. The part of the birds in our model is played by you. The length of time you "feed" on these "insects" represents one year in time. Your instructor will put the "insects" (usually 200 of each color to start) for our model in the specified area.
2. In order to make our model represent a real situation as close as possible, some rules are necessary before we start "feeding" on our "insects". In part, the success of this model is determined by your honesty in following this list of rules. Read them carefully and make sure you understand them.
   a. On signal from your instructor you will be allowed to feed for two (2) minutes. (A whole year of feeding in two minutes. WOW!)
   b. You are to walk in an upright position, bending ONLY when you see an "insect" you intend to eat. (Birds! You are not fussy about color.)
   c. You are permitted to eat ONLY ONE "insect" each time you bend and you are to take *two* normal steps before capturing your next "insect". (Even birds need a break between mouthfuls.) Do not return to the same area because you noticed other "insects" there when you captured the one you are "eating". The capturing of "insects" should be a chance event and not a conscious effort on your part to get a particular "insect".
   d. You are not to stop and survey the scene while looking for "insects". Keep moving at all times.
   e. Capture as many "insects" as you can during a run.
3. At the end of the "run" you will return to the lab, record your data in your lab book and tabulate the totals for the class. Place the total figures you obtain in a chart similar to the one accompanying this investigation, and perform the calculations necessary to fill the appropriate blanks. (Do Blanks = 4 and 6 for now —we can do = 5 when we finish the data collection.)
4. In our model we will further assume that the surviving "insects" will produce the next generation of insects and that the next generation color ratio will be determined by the surviving color ratio. (Red "insects" produce red off-

spring, green produce green.) Remember, our environment will only support 400 "insects".

5. On the basis of your class data, a new population will be re-established (total 400) and the "run" will be repeated.
6. Repeat the tabulation procedure of step three. Tabulate your information in blanks #7 through 10.

Evaluation:

1. Why were more "insects" of one of the colors captured in run one?
2. What would you normally suspect to happen if a human "bird" captured only "insects" of the color most "birds" captured occassionally?
3. If chance is the major factor involved in the capture of an "insect", how would you expect the capture percentage of run 1 and 2 to compare? How do your figures compare?
4. On the basis of your observations and calculations, what would you predict to happen to the "insect" population of our model environment if we were to continue for several more generations (runs)?
5. In a brief paragraph, summarize how selection operates to change a population.

References:

Kaupe, Roy; Simpson, Clyde; *Laboratory Manual for Biology;* Rocky River Board of Education, Rocky River, Ohio, 1972.

TABULATION TABLE: NATURAL SELECTION MODEL

(The values in parentheses are examples to help you understand the organization and chart procedure.)

	RED "INSECTS"	GREEN "INSECTS"	TOTALS
1) INITIAL POPULATION Run = 1	(200)	(200)	(400)
2) NUMBER CAPTURED	(100)	(50)	
3) NUMBER SURVIVED (Still out in the grass)	(100)	(150)	(250)
4) % OF TOTAL WHICH SURVIVED $\frac{\text{number survived}}{\text{total survived}} \times 100$	$\frac{100}{250} \times 100 = 40\%$	$\frac{150}{250} \times 100 = 60\%$	100%
5) % OF COLOR CAPTURED $\frac{\text{number captured of color}}{\text{number of color in Run Population}} \times 100$	$\frac{100}{200} \times 100 = 50\%$	$\frac{50}{200} \times 100 = 25\%$	
6) NUMBER OF INSECTS FOR RUN #2 (% survived × 400)	(.40 × 400 = 160)	(.60 × 400 = 240)	(400)
7) NUMBER CAPTURED			
8) NUMBER SURVIVED			
9) SAME AS = 4			
10) SAME AS = 5			

INVESTIGATION #31

Determination of Lead in the Environment

Background:

The average urban resident of an industrialized area has about 100 times as much lead in his system as a person who lives in a rural area. Should we be concerned about this concentration of lead in our body? Yes! When lead enters the body, it moves around until it is deposited in the bones. While it is in the blood stream, lead can be harmful to the kidneys and interfere with the production of red blood cells. Higher concentrations of lead ingested into ones system can cause vomiting, constipation and stomach cramps. It can cause damage to the nervous system and even death.

Lead poisoning is a problem in the ghettos of large cities where children sometimes eat chips of paint. Such paint is of the old variety that con-

tained a high concentration of lead. Another problem found in the ghetto and the inter-city is the high lead content of internal combustion engine exhausts.

On the lighter side one source of lead poisoning we rarely see in Rocky River is from "MOONSHINE". This is illegal whiskey which has been distilled on a homemade still which used lead tubing in the condenser. It may seem funny to us, but it is a serious problem in states or areas where "MOONSHINE" is a popular beverage.

In this investigation, we will learn how to detect the presence of lead in various compounds. A similar technique may be used for most any substance.

Objectives:

The student can accurately determine if lead is present in a compound.

Material:

ring stand
500 ml beaker
test tube
test tube clamp
Bunsen burner
paint chips
1% Na_2SO_3
20% ki
concentrated HNO_3

Procedure:

1. Bring in 1 g of paint chips or putty from home. Make sure they are free of wood or other materials.
2. Weigh out 0.10 g of paint chips or putty. Place them in a test tube.
3. Add three drops of concentrated nitric acid (HNO_3).
4. Place the test tube in a boiling water bath for 15 minutes. (Water bath should be under the hood due to the fumes)
5. Remove the tube from the boiling water bath and add 2 ml of distilled water. Paint collected from a gilted radiator may contain interfering elements such as Ag, Tl or Hg. If so, add 2 ml of 1% Na_2SO_3 instead of distilled water.
6. Allow the test tube to stand undisturbed for ten minutes then transfer the clear liquid to a clean test tube.
7. Place the test tube in a warm water bath at about 65°C. for five minutes and add ten drops of KI. *Do NOT shake the tube!* If more than 1% lead is present in the original sample, you will get a yellow precipitate of lead iodide, PbI_2.

Evaluation:

1. List five other possible sources of lead in our environment.
2. Why does the city dweller have more lead in his system than the country dweller?
3. What can we do to help prevent lead poisoning?

For further investigation:

1. Devise methods of determining the presence of lead in one of the five sources you listed in question one. Test your method to see if it works.
2. Determine if lead is present in automobile exhaust.
3. Determine if lead is present in evaporated milk. (The can is sealed with lead).

INVESTIGATION #32

What Is Turbidity?

Background:

Turbidity is an estimate of the amount of suspened solid matter in a water sample. It is measured with an instrument called a turbidimeter which relies on how much of a beam of light is scattered by the particles in the water. We can use the Hach Kit colorimeter with the turbidity scale in our test. It will measure the turbidity in the standard units known as Jackson Turbidity Units, JTU, for short. The Hach Kit is very accurate when the turbidity is above 25 JTU. The range of turbidity is from 1 JTU for treated and filtered drinking water to over 1000 JTU for raw sewage or silt-laden rivers.

Objectives:

1. The student can determine the turbidity in JTU for a water sample using the Hach Kit.

Materials:

water sample bottle
Hach Kit

Procedure:

1. Take a water sample from a natural water source. Using the directions for the colorimeter in the Hach Kit, determine the turbidity.

Discussion:

1. What type of particles contribute to the increase in turbidity?
2. How does the colorimeter in the Hach Kit measure the turbidity?
3. What are the effects of high turbidity on biological life?

Evaluation:

Laboratory report
Questions
Quiz

INVESTIGATION #33

Transparency of Water

Background:

An indication of the amount of suspended matter in water can be obtained by the use of a Secchi disc. This is a round metal disc, 20 cm in diameter. The disc is divided into quarters and painted in alternating white and black.

Several kinds of information may be gathered from the use of the Secchi disc: a. rough measurement of suspended solids, b. the depth of reflected light penetration, and c. a rough estimate of the extent of the littoral zone.

Secchi disc readings can vary with the surface conditions of the water, color of the water, and the angle of the sun. Usually if the Secchi disc reading is low (4–5 feet or 1½–2 meters), the water contains large quantities of suspended matter. If the Secchi disc reading is high (25–30 feet or 7–10 meters) the water is low in suspended solids.

Due to the variability of the reading caused by factors other than suspended solids, it is always recommended that repeated measurements be taken at different times and then averaged.

Objectives:

1. The student can correctly determine if the quantity of suspended solids are high, low, or moderate.
2. The student can determine the approximate depth of reflected light penetration.
3. The student can determine the approximate depth of the littoral zone.

Materials:

Secchi disc
rope, marked in feet or meters
bucket with plexiglass bottom
boat

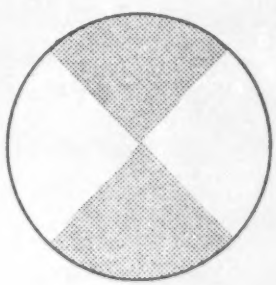
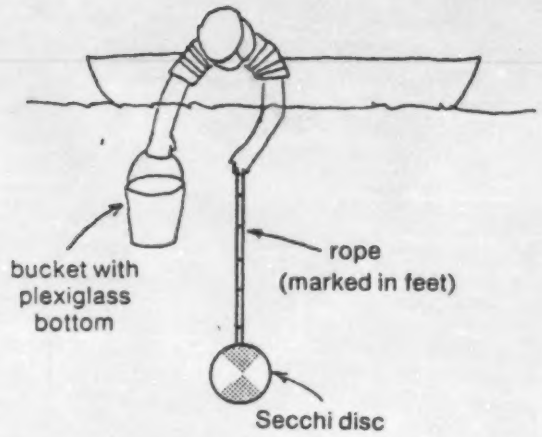


Figure 1

Figure 2



Procedure:

1. Obtain a Secchi disc reading by lowering the disc into the water until it just disappears. (Figure =1) Take and record a depth measurement.
2. Raise the disc until it just reappears. Take another depth measurement and record.
3. Average the two measurements. Repeat this process three or more times. The overall average is the Secchi disc reading.
4. Note the surface conditions at the time. You may use a bucket with a plexiglass bottom to make your work more accurate. (Figure #2)
5. Estimate the amount of suspended solids. (High — less than five feet. — Moderate — greater than five feet, but less than fifteen feet. — Low — greater than fifteen feet.)
6. Estimate the depth of reflected light. This is the point where the Secchi disc reappears. (Step 2)
7. Estimate the depth of the littoral zone. (The depth of light penetration as found in Step 3)

Evaluation:

1. Why do you think we use black and white as the colors on the Secchi disc? Why not red and green?
2. What is the littoral zone?
3. What are the effects of high suspended solids on biological life?

Reference:

Andrews, W. A., *A. Guide to the Study of Freshwater Ecology;* Prentice Hall, Englewood, New Jersey, 1972.

INVESTIGATION #34

Wild Foods . . . Follow the Euell Gibbons Route

Background:

Many tasty and highly palatable wild foods can still be found in this modern era where the trend is towards large cement-covered cities and sprawling suburbia. They grow in profusion in our back yards, vacant lots, fields, parks and small wood lots. Many of these wild foods would seem to fall within the ordinary gardener' definition of a weed.

Objectives:

1. To locate and identify the four common wild foods indicated in this activity.
2. To research ways to use each of these wild foods.
3. To prepare a vegetable dish or salad from one of the four wild foods mentioned in this activity.
4. To read and report on various American Indian tribes and their uses of wild plants, including plantain, curly dock, cattails, and dandelions.
5. To learn the useful structures of each wild food in this activity.

Materials:

notebook and pencil
four plastic bags
small trowel
dissecting microscope
hand lens
reference materials on common plants
refrigerator
stove

Procedure:

1. Carry out this activity in spring or early fall.
2. Read as much as you can about the following plants: Plantain, curly dock, cattails, and dandelions. Such reading is a prerequisite to the actual identification and subsequent collection of the one wild food to be prepared in this activity. It would be wise to take careful notes as you do your reading.
3. Research various American Indian wild foods before going into the field. This work can be done after the field and laboratory work, however.

4. Look for the common plantain, curly dock, cattails, and dandelions at the Outdoor Education Center. When you find each, note where it is found and what other vegetation is near. Describe the soil conditions in the area where the plant is located.
5. Collect a sample of each of the above plants and be sure to include the roots. Keep the plants in plastic bags.
6. After returning to the laboratory, study each specimen carefully. Sketch and label the parts. Use reference material when needed.
7. Place your plants in the plastic bags and store them in the refrigerator.
8. Find other students who plan to prepare the same food and collectively supply the necessary ingredients.
9. Prepare your dish and sample each of the other foods prepared by your class members.

Additional Information:

1. Common plantain has thick leaves that are long, heartshaped, and noticeably ribbed in appearance. The flower stalk is tall (three to ten inches) and bears tiny, insignificant greenish flowers during the blooming season of April to Oct.
2. Curly dock is easily identified by its long, lance-shaped, curly edged leaves. The plant usually grows from two to five feet in height with the largest leaves coming from the stem at ground level. The leaves growing higher up on the stem are always much smaller in size. The base leaves often reach six to twelve inches in length and have a slimy sort of membrane covering them where they join the stem of the plant.
3. The common cattails are found in marshes and wetlands. Cattails can be identified by their long flat leaves which are sword-shaped, light green and usually grow a bit higher than the flower-stock. The upper portion of the long, cylindrical-shaped flower spike bears the stamens, and is a light brown color; the lower portion bears the pistils and is the familiar brown cattail we recognize.
4. The dandelion is the fourth wild food we considered and it is so well known that no description need be given.

Discussion:

1. Which of the wild foods do you like best?
2. An adage for safety in food consumption is, "If it's natural, it's got to be good!" Is this statement true or false?
3. What precautions should you follow in regard to eating wild foods?
4. What structures in each of the four wild plants studied are edible?
5. Besides food, what other uses did the American Indians make of the wild plants we have studied?

Evaluation:

— Quiz

1. What precautions should you follow in regard to eating wild foods?
2. List the parts of the wild foods studied that provide the major food groups. (proteins, carbohydrates, vitamins, minerals, etc.)
3. If you were lost in the woods without food, discuss what wild foods you would choose and where you would look for them.

Further Inquiry:

1. Investigate the American Indian's diet to maintain or refute current health food fads in regard to health through natural foods.
2. Read one of Euell Gibbons books.
3. Prepare one of the wild dishes for your family.

References:

1. Encyclopedia Britannica, Inc., "American Indians," *Encyclopedia Britannica*, Chicago.
2. Mason, Phillip, "Camp Chef," *Camping Journal;* Volume XII, No. 11, pp. 14–15; Davis Publications, New York, August, 1974.
3. Nelson and Coon, *Using Wayside Plants;* Heartside Press, Inc., New York, 1969.
4. Wilkinson, R. E. and Jacques, H. E., *How to Know the Weeds;* Wm. C. Brown Company. Publishers, Dubuque, 1972.

INVESTIGATION #35

Chicory, a Useful Weed

Background:

WHAT IS A WEED?

A weed is "any plant which grows where it is not wanted." Most plants which are characterized as weeds possess to an unusually high degree, a capacity for vigorous growth and survival under adverse conditions.

Chicory *(Cichorium intybus)* is a common weed with bright blue flowers belonging to the Composite Family. It is a native of Europe, a perennial, and a close relative of the dandelion which it resembles when in early growth. The root is dark, contorted and wormlike in appearance, while the root of the dandelion has a smooth, light colored tap root.

The blue chicory, which grows abundantly along highways and in meadows and pastures, once was used as a salad and coffee adulterant. Early settlers roasted the large roots and ground them to add color and body to their coffee. This common weed is also used as fodder for cattle and sheep.

One of the most interesting uses of the chicory weed was employed by pioneers working in the field. They could watch the chicory flower and tell the time of day. With the coming of the sun, the flower began to open; as noon had passed, it began to fold and by night it was tightly shut. There are many chicory clocks available today, but they are not precise enough to be functional in our clock-watching generation.

Objectives:

1. To identify chicory in the field.
2. To measure the blossoms of several chicory flowers as a means of approximating the time of day.
3. To gather some chicory leaves and prepare "Braised Chicory". (optional)
4. To dig some chicory roots, roast and powder them and make chicory tea.
5. To dissect a chicory flower and identify the flower parts.
6. To list some of the beneficial uses of chicory.

Materials:

trowel or some type of digging tool
metric ruler
notebook and pencil

Procedure:

1. Locate the chicory plant while in bloom and measure five flowers. Each flower measured should be from a different chicory plant.
2. Pick a flower from one of the chicory plants. Put it into your notebook for laboratory study.
3. Dissect a chicory flower and identify its parts. Use a hand lens or dissecting microscope when needed.
4. Research and report on at least two other useful weeds. Include all references used.
5. Sample data sheet:

CHICORY FLOWER SIZE IN mm

Flower #1. _____
2. _____
3. _____
4. _____
5. _____

Time of day indicated by the average blossom size is _____.

CHICORY FLOWER DISSECTION

Check in the appropriate block if the following flower parts are present or missing.

Flower Parts	Present	Missing
Stigma		
Style		
Ovary		
Ovules		
Filament		
Anther		
Pollen		
Sepals		
Petals		
Receptacle		

Discussion:

1. From the investigation you have done, would you continue to call chicory a weed, according to the definition given for a weed? Why?
2. Have you ever tasted the chicory coffee served in New Orleans? Describe the taste? Perhaps some one can bring in some chicory that was purchased in a gourmet food store, and serve chicory coffee to the class.
3. What are some of the other useful weeds you have studied?
4. Do you think it would be good to use the edible wild plants in the same manner the pioneers did? Why or why not?
5. Why do you think chicory and dandelions are called "cousins"?
6. Are chicory flowers able to self-pollinate?

Evaluation:

— Quiz

1. List several ways that chicory can be useful to people.
2. Does the chicory blossom have male and female reproductive parts?
3. What is significant about the quality of soil where chicory is found?

Further Investigation:

1. Experiment to discover the conditions that allow a weed to become a successful weed. Using dandelions, try some of the following activities:
   a. Cut small pieces of the root and attempt to vegetatively reproduce the plant under varying conditions.
   b. Use salt in varying amounts to determine how long dandelions can survive when watered with salt water.
   c. Count seeds.
   d. Check soil depths for the presence of dandelion seeds.
   e. Duplicate the above activities using a tomato. Compare the results.

Try this:

Secure about 1½ lbs. of the tender center leaves of the chicory plant. Wash and discard the coarser leaves. Put the leaves into a thick saucepan and sprinkle with salt; add four tablespoons of butter, three tablespoons of water, and the juice of half a lemon. Cover closely, bring to a boil and simmer gently in the oven for 1 to 1½ hours. When ready, put on a hot dish and pour over a little of the reduced liquid from the saucepan. The end result is "Braised Chicory", a Nelson Coon special.

References:

1. Fogg, John M. Jr., *Weeds of Lawn and Garden, A Handbook for Eastern Temperate North America;* University of Pennsylvania Press, Philadelphia, 1945.
2. Nelson and Coon, *Using Wayside Plants;* Hearthside Press, Inc., New York, 1969.
3. Smith, Robert L., *Ecology and Field Biology;* Harper and Row, New York, 1966.
4. *The Western Reserve Magazine;* Garrestville, Ohio, Box 243.

INVESTIGATION #36

Bird Identification by Song

Background:

Why do birds sing? They apparently do not sing for the same reasons we do, although a burst of song may well be an expression of emotion. It is generally agreed that the most important functions of song are to proclaim territory and invite attention from the opposite sex.

Many of the keenest bird watchers depend more on their ears than on their eyes. Some find 90 per-cent of their birds that way. On their walks, they pause every few minutes and listen intently, for just as the voice of a friend can be recognized in the next room, so can the notes of a hidden bird be identified.

The songs of birds vary according to five characters. These are TIME, PITCH, LOUDNESS, QUALITY, and PHONETICS. By combinations of these characters we get form, rhythm, accent, and other attributes.

It isn't easy to learn bird voices from the printed page, so you may have to stalk the bird until you can get a good look at it before you will be able to make a positive identification.

Objectives:

1. To identify meadow and woodland birds by their songs using a key to bird songs.
2. To tape record various bird songs at the Outdoor Education Center.
3. To construct a musical shorthand for each bird song heard and taped.
4. To classify bird songs according to pitch and time.
5. To practice listening to bird songs.

Materials:

tape recorder
pitch-pipe
stopwatch
binoculars

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INVESTIGATION #35
Chicory, a Useful Weed

Plate # 20
CHICORY
Chichorium Intybus

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Aretas A. Saunders, *A Guide to Bird Songs*
bird song records
Peterson's *A Field Guide to the Birds*

Procedure:

1. Before going to the Outdoor Education Center, spend some time reading about the kinds of birds that inhabit the woods, brushy places, fields, and meadows. Listen to bird song recordings to attune your ears to bird sounds.
2. Take a bird walk at the Outdoor Education Center, pausing every few minutes to listen. Quietly tape record the bird songs. Indicate in your notebook where the sound was coming from, what kind of tree, etc. If possible, set up a parabolic reflector to amplify sounds. The best possible time for this activity is *early* in the morning.
3. In the laboratory, listen to your tape recording several times. Try to make musical shorthand for each bird song. Saunders, pp. 5–16.
4. Using a pitch-pipe, establish the pitch or pitches used in the bird song. Time the song.
5. Trace the bird song using *A Key to Bird Songs*. Saunders, pp. 19–39.
6. Identify each bird recorded.
7. Go back on a bird walk, listening for those bird songs you have learned and identified.
8. Play some of your taped bird songs for the class. Teach them how to listen for time, pitch, loudness, quality, and phonetics.

Evaluation:

The teacher can play a few bird song recordings (making certain that they include the ones that the student has studied) for the students to identify.

Further Investigation:

1. Take some clear, close-up photographs of the birds. (If you have access to a telephoto lens, use it.)
2. Begin your own "master bird check list" for the Outdoor Education Center.
3. Construct an inexpensive parabolic reflector to focus in on the bird sounds.

References:

1. Peterson, Roger T., *How to Know the Birds;* Houghton Mifflin Company, Boston, 1962.
2. Saunders, Aretas A., *A Guide to Bird Songs;* Doubleday and Company, Inc, New York, [illegible]4.

Recordings:

Cornell University Laboratory of Ornithology, *Bird Songs in Your Garden, A Field Guide to Eastern Bird Songs; Songbirds of America;* Houghton Mifflin Company, Boston.

INVESTIGATION #37

Mapping Bird Territories

Background:

COMPETITION

The word "competition" denotes a striving for the same thing. At the ecological level, competition becomes important when two organisms strive for something that is not in adequate supply for both of them. Thus, plants compete for light and nutrients in a forest, and animals compete for food and shelter when the latter are relatively scarce in terms of the density of animals.

TERRITORY

An interesting behavior pattern which results in intraspecific competition for space and a rather effective control of population size, is known as territoriality. It is characteristic of many species of birds and some other higher animals.

At the beginning of the breeding season, the male of a territorial species of bird will "stake out" a definite area of its habitat (that is the "territory"). and defend it against other males of the same species. The result is that no other male is allowed to enter the area. Much of the loud bird songs one hears in the spring is for the purpose of announcing to other males "ownership" of land, and not for the purpose of wooing the female, as is often supposed. A male that is successful in holding his land has a high probability of mating and nesting, while a male that is unable to establish such a territory will not breed. In many species, once the pair is formed, the female also serves a positive purpose of insuring that the complex business of caring for the nest and young will not be interrupted by the presence of other males and females.

It should be mentioned that the actual defense of the territory does not usually involve much actual fighting or other stress. Would-be invaders respect the established bird and loud song or threat displays usually are sufficient to cause the invader to withdraw. However, if one of the pair should be killed, it is very often quickly replaced by a bird from a reservoir of individuals not yet established. Therefore, since the territorial behavior pattern helps avoid both overcrowding and undercrowding, it can be said to be regulatory.

Objectives:

1. To identify some of the birds at the Outdoor Education Center.

2. To observe social behavior in birds (locating territory, etc.)
3. To describe the behavior in birds of one species (both male and female) within their territory.
4. To draw a territory map of a bird's boundaries.

Materials:

Peterson's *A Field Guide to Birds*
binoculars
notebook and pencil

Procedure:

1. Since territorial boundaries are rather rigidly maintained by birds during the breeding season, this must be a spring activity.
2. Read about social behavior, specifically territoriality in bird species, before sighting birds in the field.
3. Some of the questions to ask yourself when identifying birds are:
   a. What is the size?
   b. What is the color?
   c. What is the shape?
   d. How does it act?
   e. How does it fly?
   f. What are its field-marks?
   g. What does it sound like?
   h. Where is it found?
   i. When is it found?
4. Use Roger Tory Peterson's *A Field Guide to the Birds* for accurate identification.
5. Observe the movements of the birds during the day for several days. Plot their singing perches. Observe the locations of territorial disputes if such disputes are observed.
6. On a clear plastic overlay of the Outdoor Education Center, draw a territory map of the pair of birds you have observed. (A map of the nesting sites could be drawn on overlays and kept on file. New nesting sites could then be recorded each year using a color code to denote specific years.)

Discussion:

1. What is meant by competition in social behavior?
2. Discuss the behavior pattern of birds during the time territories are established.
3. Describe the behavior of the birds that you observe.
4. Approximately how large was a territory? Was there competition? How can you account for this?
5. Name a few of the birds that you sighted and identified as common to the Outdoor Education Center.

Evaluation:

1. Quiz over the above discussion.
2. Evaluate the territorial map.

Further Investigation:

Play back tapes of bird songs while in the field to see if birds will respond to a territorial threat.

References:

1. Cleveland Museum of Natural History, *A Fieldbook of Birds of the Cleveland Region;* Cleveland Museum of Natural History, Cleveland, 1969.
2. Odum, Eugene P., *Ecology;* Holt, Rinehart and Winston, New York, 1963.
3. Peterson, Roger T., *A Field Guide to the Birds;* Houghton Mifflin Company, Boston, 1963.
4. Peterson, Roger, T., *How to Know the Birds;* Houghton Mifflin Company, Boston, 1962.
5. Smith, Robert L., *Ecology and Field Biology;* Harper and Row, New York, 1966.

INVESTIGATION #38:

Measuring the Mineral Content of Plants — Plant-Ash Method

Background:

There are several methods for quantitative determination of the mineral content in Plants. It is also possible to determine if a plant is deficient in a particular mineral. The tests are based on known chemical tests in which the plant must be ashed so only the inorganic material remains. The ash is then put into a solution and the solution is tested.

Objectives:

1. Students can accurately perform quantitative mineral tests for sulfur, phosphorus, calcium, magnesium, sodium, potassium, iron, and manganese.
2. Students can accurately determine the mineral content of a plant.

Material:

plant tissue from various areas and different soil types
crucible
burner
oven
5% HC1
distilled water
tri-beam balance
triangle (clay)
5% $BaC1_2$, 5% K_2SO_4
ammonium molybdate solution, 5% Na_2HPO_4
50% H_2SO_4, 5% Ca $C1_2$
magnesium reagent, 5% $MgC1_2$
nichrome loop, 1% NaC1
nichrome loop, KC1 5%
2% KSCN, concentrated HC1, 1% $FeC1_3$
1% KOH, Manganese reagent $MnC1_2$
microscope slides
dropper

Procedure:

1. Measure the mass of a dry crucible to ± 0.01 g and fill the crucible ⅔ full of ground plant material which has been dried in the oven at 103°C. for two hours.
2. Remove the crucible and contents. Heat the crucible on a clay triangle using the low flame of a Bunsen burner.
3. Heat cautiously until most of the organic material has been oxidized and *do not, at any time, allow the material to burst into flame!*
4. Apply intense heat and maintain at a low red heat until the ash is free of any black or gray color (about 30 minutes). If gray persists, cool, add 2 ml of concentrated nitric acid and continue heating.
5. After ashing, cool and remeasure the mass of the crucible and contents. Record all data in your data table.
6. Dissolve the ash in 3 ml of 5% HC1. Heat to near dryness and dissolve the residue in 5 ml of distilled H_2.
7. Carry out the following tests for the different elements. It may be necessary to use a microscope to examine the precipitate. Compare your tests with control reagents containing the element being tested. Record your results in the proper table.
   a. Sulfur: To 1 drop of ash solution on a microscope slide, add 1 drop of 5% $BaC1_2$. A white, fine crystalline precipitate of $BaSO^4$ indicates the presence of sulfur. As a control test, perform the test simultaneously on 1 drop 5% K_2SO_4.
   b. Phosphorus: To 1 drop of ash solution on a microscope slide, add one drop ammonium molybdate reagent, Yellow, crystalline cubes or octahedrons of ammonium phosphomolybdate indicate the presence of phosphorus. Apply this test on 1 drop 5% Na_2HPO_4.
   c. Calcium: To 1 drop of ash solution on a microscope slide, add one drop 50% H_2SO_4. Needle-like crystals of $CaSO_4$ indicate the presence of calcium. Run a control test on 1 drop 5% $CaC1_2$.
   d. Magnesium: To 1 drop of ash solution on a microscope slide, add one drop magnesium reagent. A precipitate of ammonium phosphate indicates the presence of magnesium. Also, test 1 drop 5% $MgC1_2$.
   e. Sodium: Suspend 1 drop of ash solution in a loop of nichrome and hold the drop in a Bunsen burner flame. A yellow flame indicates the presence of sodium. Run a control test on 1 drop 1% NaC1. Clean the wire before and after use by alternately dipping into concentrated HC1 and heating it to incandescence.
   f. Potassium: Thoroughly clean a loop of nichrome and suspend a drop of ash solution in a Bunsen burner flame. Observe the flame through two layers of cobalt glass. A violet flame indicates the presence of potassium. Run a standard test on 1 drop 5% KC1.
   g. Iron: To 1 drop of ash solution on a white spot plate, add 1 drop 2% KSCN and 1 drop concentrated HC1. A red color of potassium ferrithiocyanate ($K_3Fe(SCN)_6$) indicates the presence of iron. Run a control test on 1 drop 1% $FeC1_3$.

h. Manganese: Place 1 drop of ash solution on filter paper and add 1 drop manganese reagent. A blue color immediately upon adding the manganese reagent confirms the presence of manganese. Run a control test on 1 drop 1% $MnCl_2$.

Procedure:

8. Construct a data table as follows:

A. Yield of Ash

Species of plant studied:	
Mass of crucible and dry plant	g
Mass of crucible	g
Mass of dry plant	g
Mass of crucible and ash	g
Mass of crucible	g
Mass of ash	g
% ash of dry plant	%
% organic matter of dry plant	%
Assuming that before being dried the fresh plant contained 90% water, what is the % ash on a fresh mass basis?	%

B. Ash Analysis

Species Analyzed:				
	Control Test		Test on Ash	
Element Tested	Observations	Conclusion	Observations	Conclusion
S				
P				
Ca				
Mg				
Na				
K				
Fe				
Mn				

References:

1. Arditti, Joseph and Dunn, Arnold, *Experimental Plant Physiology:* Holt, Rinehart and Winston, Inc., New York, 1969.
2. Kurtz, Edwin, B. Jr., Mellor, Robert S., *Plant Physiology Laboratory Exercises;* Burgess Publishing Company, Minneapolis, 1966.

INVESTIGATION #39

Detection of Sulfur Dioxide

Background:

One of the most common and most abundant air pollutants in the air today is sulfur dioxide. More than half of the sulfur dioxide produced by man's activities originates from the production of electrical power. The remaining half is produced by factories, steel mills, and the heating of homes. Much of the sulfur dioxide produced by industries is related to releasing metals from their ores. Sulfide ores such as sphalerite (ZnS), iron pyrite (FeS_2), fool's gold (FeS), and chalcocite (CuS) have the metals removed by exposure to oxygen at high temperatures. The following equation represents this type of chemical oxidation:

$$CuS_{(s)} + O_{2\,(g)} \longrightarrow Cu_{(s)} + SO_{2\,(g)}$$

Many large cities in the United States have high concentrations of sulfur dioxide in the atmosphere because they burn large quantities of coal and fuel oil for heat and power. The sulfur in the hydrocarbons is oxidized in the following manner:

$$S_{(s)} + O_{2\,(g)} \longrightarrow SO_{2\,(g)}$$

In this experiment we are going to use a well known characteristic of the elements located at the right side of the periodic table. (These include sulfur). Oxides of nonmetals react with water to form solutions which are distinctly acidic. Oxides of this type are called acid anhydrides. The equation for this reaction is:

$$SO_{2\,(g)} + H_2O_{(l)} \longrightarrow \underset{\text{sulfurous acid}}{H_2SO_{3\,(aq)}}$$

Objectives:

1. The student is able to test vapors for the presence of sulfur dioxide.
2. The student can correctly test water for alkalinity or acidity using litmus paper.

Materials:

deflagrating spoon
0.2 g of sulfur
gas collecting bottle
red and blue litmus paper
Bunsen burner
glass plate

Procedure:

1. Fill a gas collecting bottle about ⅓ full with distilled water. Cover the bottle with a glass plate.
2. Place a small lump of sulfur (no more than 0.2 g) in a deflagrating spoon.

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3. *The following step should be done with all equipment under a fume hood!* Hold the deflagrating spoon over a Bunsen burner until the sulfur ignites. Sulfur will burn with a light blue color flame. Quickly insert the burning sulfur into the gas collecting bottle. Cover the bottle as completely as possible with the glass plate. When combustion is complete, remove the spoon.
4. Shake the bottle for thirty seconds or more.
5. Test the solution in the bottle. First with red litmus paper. Next use blue litmus paper. If a pH meter is available, test your solution for the pH.

Evaluation:

1. How is sulfur dioxide produced?
2. Why do we shake the bottle in step four?
3. What color did the red litmus paper turn? What color did the blue litmus paper turn? Why? What does this indicate?

References:

Gordon, Glen, *The Delicate Balance;* Harper and Row, New York, 1973.

INVESTIGATION #40

Acid Rains

Background:

The more we learn about air pollution, the more we see its side effects. Air pollution is a hazard to man's respiratory system. In recent years we have found that air pollution has also been the cause of millions of dollars of damage to roads, buildings and other structures. This damage has been caused by "acid rains."

What is an acid rain? An acid rain occurs when rain falling through the atmosphere picks up particles of pollution. These particles are dissolved and change the water from a neutral solution to a acidic solution. This acid then attacks the roads, and buildings causing them to deteriorate much more rapidly. One of the major causes of acid rains is the pollutant SO_2 which combines with water to form H_2SO_3 or sulfurous acid.

In this investigation we will test the pH of the rain for the presence of acid. We will see what factors affect the quantity of acid in the rain.

Objectives:

1. The student is able to determine the pH of rain water.
2. The student can describe the possible sources of acid rain.

Materials:

rain gauage
mounting base with direction indicator
wind gauge (velocity and direction)
pH paper
pH meter — optional

Procedure:

1. Choose several sites at different points along the Rocky River. Place an identification stake in the ground so you collect at the same site each time.
2. When it rains, place the gauge at your collection site. At the same time record the wind direction and velocity. If you don't have instruments to measure these, call the weather station for help. Call WE-1-1212.
3. When the rain stops, collect your rain sample. Record the amount of rainfall.
4. Test the rain water for the pH with either pH paper or a pH meter. Record the pH on your data sheet. Record the high and low temperature of ther day.

DATA TABLE

Date	Amount of Rain mls	pH	Method	Wind Direction	Temperature Range

Evaluation:

1. Why is it important to study acid rains?
2. What are different pollutants which can produce acid rains?
3. Why is the wind an important factor to consider in this study?
4. What is good about an acid rain?

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FILMS

The following films can be used to support *Field Ecology:*

Code	Sources
EBF	Encyclopaedia Britannica Films, Inc. 1150 Wilmette Avenue Wilmette, Illinois 60091
IFB	International Film Bureau 332 South Michigan Avenue Chicago, Illinois 60604
McG	McGraw Hill Text Films 330 West 42nd Street New York, New York 10036
NFBC	National Film Board of Canada 680 Fifth Avenue New York, New York 10019
SCS	Soil Conservation Service Motion Picture Library Box 11222 Fort Worth, Texas 76110
SHELL	Shell Film Library 450 Meridian Street Indianapolis, Indiana 46204
USFS	U. S. Department of Agriculture Forestry Service Washington, D. C.

Titles

The Stream .....Color — 15 min. — IFB
The Community .....Color — 11 min. — EBF
Life in the Forest.....Color — 12 min. — EBF
Life in the Grasslands ....Color — 12 min. — EBF
Population Ecology .....Color — 28 min. — McG
The Pond .....Color — 20 min. — IFB
The Web of Life Series ...Color — 30 min. — EBF
World in a Marsh .....Color — 22 min. — NFBC
Population Ecology .....Color — 19 min. — EBF
Deep Roots.....Color — 39 min. — SCS
The Forest Produces.....Color — 11 min. — EBF
Vacant Lot .....Color — 21 min. — IFB
Plant Succesion .....Color — 15 min. — McG
The Prairie .....Color — 18 min. — IFB
The River Must Live.....Color — SHELL
The Changing Forest .....Color — 19 min. — McG
Life in the Woodlot .....Color — 17 min. — McG
Realm of the Wild .....Color — 25 min. — USFS
Succession: From Sand Dune
to Forest.....Color — 17 min. — EBF
The Temperate Deciduous
Forest .....Color — 17 min. — EBF
World of Microbes .....Color — 30 min. — McG
Yours is the Land .....Color — 21 min. — EBF

FIELD ECOLOGY

Investigation Evaluation

Please complete an evaluation for each activity undertaken. This instrument is to be used by students, volunteers and teachers.

Investigation Number _____

Investigation Title _____
Person completing this evaluation: *Student, Volunteer, Teacher (circle)*

1. Could you understand the directions in the procedure? Yes _____ No _____
   Please comment.

2. Was this investigation workable? Yes _____ No _____
   Please comment.

3. Did you or your students meet the objectives of the investigation?
   Please comment. Yes _____ No _____

4. Rate your evaluation of this investigation. (circle one)
   Excellent Good Average Below Average Poor

5. Please give suggestions for improvement of this investigation.

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SUPPORTIVE RESOURCE MATERIALS

No. of Copies	Author	Title
1	Conrad	How to Know Mosses and Liverworts
5	Eddy & Hodson	Taxonomic Keys to the Common Animals of the North Central States
3	Harlow	Fruit Key and Twig Key
5	Harlow	Trees of the Eastern and Central United States and Canada
5	Jacques	How to Know Insects
5	Needham	A Guide to the Study of Freshwater Biology
22	Odum	Ecology
2	Odum	Fundamentals of Ecology
1	Parsons	How to Know the Ferns
5	Peterson	A Field Guide to the Birds
5	Pohl	How to Know the Grasses
5	Prescott	How to Know Freshwater Algae
5	Smith	Ecology and Field Biology
3	U. S. En. Protection Agency	Field Laboratory Methods for Measuring the Quality of Surface Water and Effluents

EQUIPMENT AND SUPPLIES

Item =	Quantity	Description
1	5	Aquarium, 10 gallon
2	1	Axe, Estwing
3	10	Binoculars, 7 × 35 Center Focus
4	6 pr.	Boots, Hip, Sizes 6, 8, and 10
5	24	Bottles — Nalgene, Narrow Mouth — 32 oz.
6	3	Broth, Endo — Total Coliform
7	1	Broth, Fecal Coliform
8	5	Cell, Sedgewick Rafter, Counting
9	2 ctns.	Dishes, Plastic Petri, Millipore
10	1	Disk, Secchi
11	100	Driers, Botanical 19" × 12" (For use with Plant Presses)
12	2	Filters, H. A. White Grid, Millipore
13	2	Filters, Aquarium
14	2	Forceps, Stainless Steel, Millipore
15	6	Gauges, Rain
16	1	Hach, Water Test Laboratory
17	1	Hammer, Sledge, 6 lb.
18	2	Holder, Millipore Filter
19	2	Meter, Wind, Hand Held
20	3	Net, Aquatic, D Frame
21	10	Net, Insect, Standard

Item =	Quantity	Description
22	3	Net, Sheet, Beating
23	6	Net, Sweeping
24	1	Net, Wisconsin Plankton
25	12	Pans, Enamel, Collecting
26	1	Pedometer
27	10	Presses, Plant
28	2	Psychrometer, Sling, Pocket Style
29	2	Pump, Aquarium
30	1	Pump, Vacuum, Hand Operated
31	1	Sampler, Ekman Bottom
32	1	Sampler, Water, Kemmer
33	1	Saw, Two Man Crosscut
34	1	Saw, Swedish Bushman's
35	2	Seine, Minnow
36	2	Shears, Looping
37	1	Shears, Pruning
38	2	Shovels, Long Handled
39	12	Shovels, Short Handled, Military
40	5	Sieves, Brass, #30 Mesh
41	6 sets	Sieves, Plastic, Soil
42	2	Slips, Cover, Sedgewick
43	2	Tape, Measuring, 20 m, Metric
44	3	Thermometer, Soil
45	12	Trap, Live Animal, Small
46	5	Tubes, Soil Sampling
47	100	Ventilators, Botanical (for use with plant press)
48	144	Vials, 8 dram, Snap Cover (for collecting specimens)
49	144	Vials, Glass (plastic screw cap, 33mm × 85mm for collecting specimens)
50	5	Wheel, Trundle, Metric (for horizontal measurements)
51	1	Wheelbarrow

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REQUISITION FOR ECOLOGY BOOKS, EQUIPMENT AND SUPPLIES

Teacher making request _____ Date _____

School _____ Date(s) needed _____

Please submit all requests for materials to the Project ENRICH Office two weeks prior to the date needed.

Equipment and Supplies

Quantity	Item #	Description

Books

Quantity	Author	Title

FOR OFFICE USE

Date requisition was received _____ Date Filled _____
Comments on condition or shortages:

Date materials were returned _____ Comments on condition or shortages

_____

_____

_____

REQUEST FOR PROJECT ENRICH VOLUNTEER FIELD TRIP ASSISTANCE

Teacher making request _____ Date _____

School _____ Grade level _____

Field Trip Date _____ Beginning time _____

Ending time _____

Specific activities to be covered:

Special instructions for volunteers:

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FOR OFFICE USE

_____ Field trip scheduled

_____ Date approved

_____ Sorry cannot schedule field trip on this date. Please select alternate day.

Volunteers assigned:

_____ _____

_____ _____

_____ _____

_____ _____

AUDIO-TUTORIAL PROJECT PROPOSAL

Name of Student or Students Responsible	Grade Level	School	Sponsor

Audio-Tutorial Topic _____

Briefly outline topic content:

FOR OFFICE USE

Approved _____ Screened by: _____

Not approved _____ _____

_____

Comments:

89

TRANSPORTATION REQUEST — LEASED SERVICES

Requested by	School	Departure Date	No. of Passengers
Destination	Address	Departure Time	Return Time
Alternate Date	Date of Application	Total Estimated Miles	

Activities supported by this field trip _____

Comments: _____

Complete in duplicate. Return one copy and submit one copy to the Office.

Approved (Principal)

For Office Use

Approved by Project ENRICH Office

Contracting Agency

Estimated Cost

Actual Cost